January,
1972
Price, $1.25

Management vs. Control in the Construction of Power Plants

Evaluating Transport Systems as Energy Consumers

Energy for the Future: How New Technology Can Help

Simple Technology in the Service of Students and Teachers

Environmental Improvement Depends on Flexible Constraints

Technology Review

Edited at the
Massachusetts Institute
of Technology

Fusion:

Searching for the "Lost Dutchman" Mine

technology
review
Published by MIT

SPECIAL REDUCED RATES FOR YALE ALUMNI

EIGHTH ANNUAL TOUR PROGRAM—1972

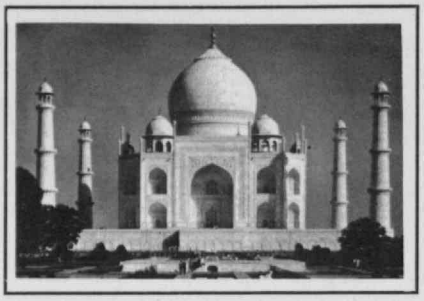
This unique program of tours is offered to alumni of Harvard, Yale, Princeton, M.I.T., Cornell, Dartmouth, Univ. of Pennsylvania and certain other distinguished universities and to members of their families. The tours are based on special reduced air fares which offer savings of hundreds of dollars on air travel. These special fares, which apply to regular jet flights of the major scheduled airlines but which are usually available only to groups and in conjunction with a qualified tour, are as much as $500 less than the regular air fare. Special rates have also been obtained from hotels and sightseeing companies.

The tour program covers areas where those who might otherwise prefer to travel independently will find it advantageous to travel with a group. The itineraries have been carefully constructed to combine the freedom of individual travel with the convenience and savings of group travel. There is an avoidance of regimentation and an emphasis on leisure time, while a comprehensive program of sightseeing ensures a visit to all major points of interest. Hotel reservations are made as much as a year and a half in advance to ensure the finest in accommodations.

EAST AFRICA

22 DAYS $1699

A luxury "safari" to the great national parks and game reserves of Uganda, Kenya and Tanzania. The carefully planned itinerary offers an exciting combination of East Africa's spectacular wildlife and breathtaking natural scenery: great herds of elephant and a launch trip through hippo and crocodile in **MURCHISON FALLS NATIONAL PARK;** multitudes of lion and other plains game in the famed **SERENGETI PLAINS** and the **MASAI-MARA RESERVE;** the spectacular concentration of wildlife in the **NGORONGORO CRATER;** tree-climbing lions around the shores of **LAKE MANYARA;** the **AMBOSELI RESERVE,** where big game can be photographed against the towering backdrop of snow-clad Mt. Kilimanjaro; and the majestic wilds of **TSAVO PARK,** famed for its elephant and lion as well as its unusual Mzima Springs. Also included are a cruise on **LAKE VICTORIA** in Uganda and visits to the fascinating capital cities of **KAMPALA** and **NAIROBI.** The altitude in East Africa provides an unusually stimulating climate, with bright days and crisp evenings (frequently around a crackling log fire), and the tour follows a realistic pace which ensures a full appreciation of the attractions visited. Total cost is **$1699** from **New York.** Optional extensions are available to the famed **VICTORIA FALLS,** on the mighty Zambezi River between Zambia and Rhodesia, and to the historical attractions of **ETHIOPIA.** Departures in January, February, March, May, June, July, August, September, October, November and December 1972 ($25 additional for departures in June, July, August).



THE ORIENT

30 DAYS $1759

1972 marks the eighth consecutive year of operation for this outstanding tour, which offers the greatest attractions of the Orient at a sensible and realistic pace. Twelve days are devoted to the beauty of **JAPAN,** visiting the ancient "classical" city of **KYOTO,** the modern capital of **TOKYO,** and the lovely **FUJI-HAKONE NATIONAL PARK,** with excursions to ancient **NARA,** the magnificent medieval shrine at **NIKKO,** and the giant Daibutsu at **KAMAKURA.** Visits are also made to **BANGKOK,** with its glittering temples and palaces; the fabled island of **BALI,** considered one of the most beautiful spots on earth; the ancient temples near **JOGJAKARTA** in central Java; the mountain-circled port of **HONG KONG,** with its free port shopping; and the cosmopolitan metropolis of **SINGAPORE,** known as the "cross-roads of the East." Tour dates include outstanding seasonal attractions in Japan, such as the spring cherry blossoms, the beautiful autumn leaves, and some of the greatest annual festivals in the Far East. Total cost is **$1759** from **California, $1965** from **Chicago,** and **$2034** from **New York,** with special rates from other cities. Departures in March, April, June, July, September and October 1972.

AEGEAN ADVENTURE

22 DAYS $1329

This original itinerary explores in depth the magnificent scenic, cultural and historic attractions of Greece, the Aegean, and Asia Minor—not only the major cities but also the less accessible sites of ancient cities which have figured so prominently in the history of western civilization, complemented by a luxurious cruise to the beautiful islands of the Aegean Sea. Rarely has such an exciting collection of names and places been assembled in a single itinerary—the classical city of **ATHENS;** the Byzantine and Ottoman splendor of **ISTANBUL;** the site of the oracle at **DELPHI;** the sanctuary and stadium at **OLYMPIA,** where the Olympic Games were first begun; the palace of Agamemnon at **MYCENAE;** the ruins of ancient **TROY;** the citadel of **PERGAMUM;** the marble city of **EPHESUS;** the ruins of **SARDIS** in Lydia, where the royal mint of the wealthy Croesus has recently been unearthed; as well as **CORINTH, EPIDAUROS, IZMIR** (Smyrna) the **BOSPORUS** and **DARDENELLES.** The cruise through the beautiful waters of the Aegean will visit such famous islands as **CRETE** with the Palace of Knossos; **RHODES,** noted for its great Crusader castles; the windmills of picturesque **MYKONOS;** the sacred island of **DELOS;** and the charming islands of **PATMOS** and **HYDRA.** Total cost is **$1329** from **New York.** Departures in April, May, July, August, September and October, 1972.

MOGHUL ADVENTURE

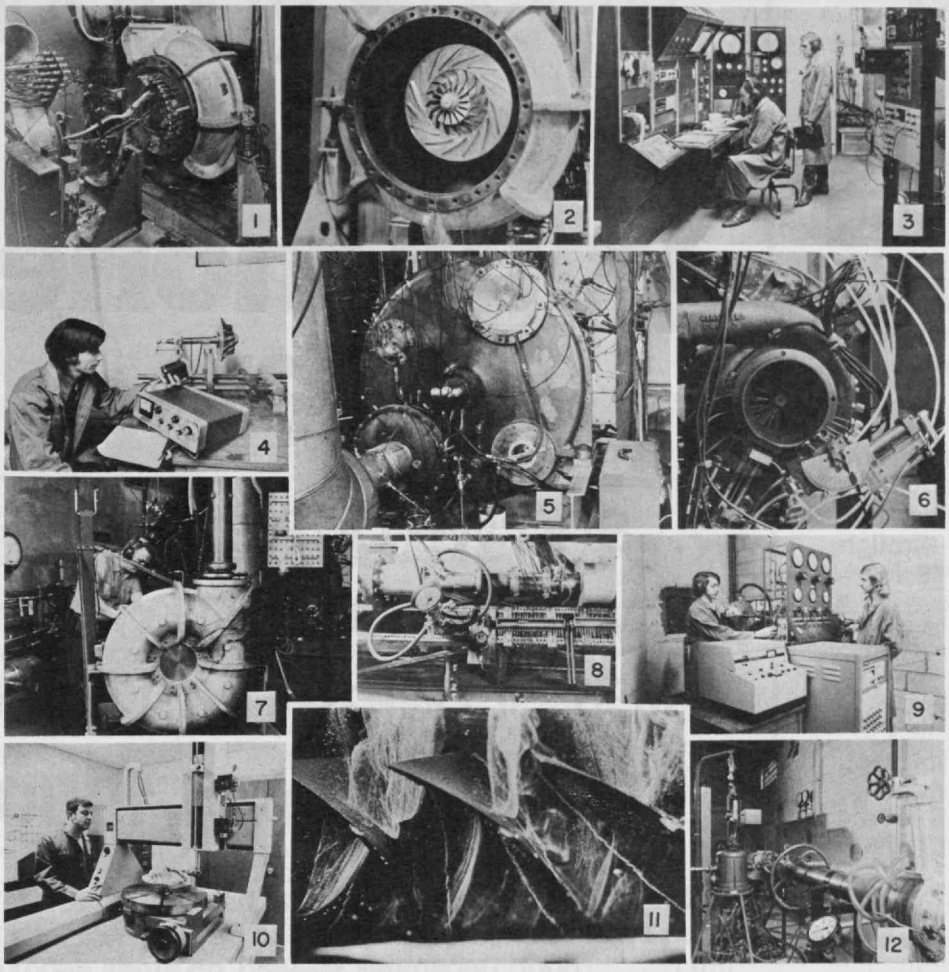
29 DAYS $1725

An unusual opportunity to view the outstanding attractions of India and the splendors of ancient Persia, together with the once-forbidden mountain kingdom of Nepal. Here is truly an exciting adventure: India's ancient mounuments in **DELHI;** the fabled beauty of **KASHMIR** amid the snow-clad Himalayas; the holy city of **BANARAS** on the sacred River Ganges; the exotic temples of **KHAJURAHO;** renowned **AGRA,** with the Taj Mahal and other celebrated monuments of the Moghul period such as the Agra Fort and the fabulous deserted city of Fatehpur Sikri; the walled "pink city" of **JAIPUR,** with an elephant ride at the Amber Fort; the unique and beautiful "lake city" of **UDAIPUR;** a thrilling flight into the Himalayas to **KATHMANDU,** capital of **NEPAL,** where ancient palaces and temples abound in a land still relatively untouched by modern civilization. In **PERSIA** (Iran), the visit will include the great 5th century B.C. capital of Darius and Xerxes at **PERSEPOLIS;** the fabled Persian Renaissance city of **ISFAHAN,** with its palaces, gardens, bazaar and famous tiled mosques; and the modern capital of **TEHERAN.** Outstanding accommodations include hotels that once were palaces of Maharajas. Total cost is **$1725** from **New York.** Departures in January, February, August, October and November 1972.

Rates include Jet Air, Deluxe Hotels, Most Meals, Sightseeing, Transfers, Tips and Taxes. Individual brochures on each tour are available.

For Full Details Contact:

ALUMNI FLIGHTS ABROAD
White Plains Plaza
One North Broadway
White Plains, N.Y. 10601



1. Gas turbine drive—turbomachinery performance testing.
2. Centrifugal compressor stage performance testing.
3. Data acquisition system.
4. Balancing of rotor system.
5. Radial compressor performance testing.
6. Turbocharger performance investigation.
7. Centrifugal compressor discharge volute test.
8. Supersonic combustor test rig.
9. Gas chromatograph instrumentation.
10. Impeller dimension inspection.
11. Flow visualization test via hydrogen bubbles.
12. Aircraft gas turbine combustor emission investigation.

The Acid Test . . .

of product development comes when you place the prototype component on test for the first time in the laboratory. NREC maintains extensive experimental facilities for turbomachinery and gas turbine testing which can be made available on relatively short notice to interested organizations. If you are interested in further details on our facilities, please write to the Marketing Department, Northern Research and Engineering Corporation, 219 Vassar Street, Cambridge, Massachusetts 02139, or call 617 491-2770.

Northern Research and Engineering CORPORATION

PRINCIPAL OFFICES are located in Cambridge, Massachusetts and London, England.

SALES REPRESENTATION in Washington, D. C., and Grenoble, France.

Technology Review

Edited at the
Massachusetts Institute of Technology
Volume 74, Number 3
January, 1972

Articles

Departments

First Line

A New Look of Science

Many of *Technology Review's* readers made their first acquaintance with technology in an era when science and engineering—in contrast to most other human preoccupations—were considered to be "exact," capable of wholly rational, quantitative analysis in which emotional and political issues could—and should—play no part. The sciences have not changed; but any theory which proclaims their nonpolitical isolation from world contentions and prejudices is revealed as illusion.

Even in the months since this volume of *Technology Review* began, the evidence is overwhelming:

☐ The most obvious and dismal example occurs in the effort of the Operations Research Society of America, to develop an expression of ethics which will uniquely serve practitioners of operations analysis. The Society's project turned into an attack on three non-members who sought to question a series of conclusions drawn from classified data on A.B.M. defensive installations and from estimates of offensive capabilities. The Society's purpose may have best been served when Joseph Alsop preached the warning that "a great deal of the more left-wing 'scientific' evidence must now be expected to be as a ram's horn."

☐ Though the Congress approved and appropriated it, the Office of Management and Budget is withholding over $30 million from the National Science Foundation for its institutional programs. Is it an effort to control government spending and so to tame the nation's inflation, or is it a more political move to reduce the government's commitment to graduate-level excellence in science and technology?

☐ There was never anything "secret" in the military sense about the final report of the Office of Science and Technology, *ad hoc* supersonic transport review committee submitted to O.S.T. on March 30, 1969. But it was not released for public discussion until September, 1971, several months after Congress, supposed to be responsive to an informed public opinion, had made its S.S.T. decision. The report, as it turned out, advised ending the S.S.T.

project for reasons having to do with both technical and economic uncertainty. ☐ Environmental Impact Statements are now required before work can proceed on many federally funded engineering and development projects, and the literature of environmental control abounds with data about expanding airports and highways, "clearing and snagging" waterways, and sales of government property for development. But the Environmental Impact Statement covering one of the largest government-funded engineering enterprises—the Cannikin nuclear test in the Aleutians—remained classified in whole, despite an international public need for the best scientific estimates of the test's potential for damage.

A longer recital of events and circumstances could only add evidence to the proposition that science is now tightly held by circumstance and exploitation to many partisan political issues. The vision of the scientist in his curtained laboratory, insulated from the world of which he seeks the truth, may always have been apocryphal; it is now a full-fledged myth. That scientists—and their institutions—must have special roles in the political arena is now self-evident.—J.M.

Technology Review, Reg. U.S. Patent Office, is published nine times each year (in October/November, monthly from December through June, and in July/August) at the Massachusetts Institute of Technology. Copyright 1972 by the Alumni Association of the Massachusetts Institute of Technology.

Inquiries regarding editorial contents, subscriptions, and advertising should be addressed to: Technology Review, Room E19-430, Massachusetts Institute of Technology, Cambridge, Mass., 02139. Telephone area code (617) 864-6900, ext. 4872. Technology Review is printed by the Lew A. Cummings Company, Manchester, New Hampshire. Second class postage paid at Boston, Mass., and at additional mailing offices.

Price: $1.25 per copy, $9 per year in the United States, $10 in Canada and foreign countries. Please allow three weeks for changes of address, and give both old and new addresses in all requests.

Technology Review is represented for advertising by: MediaRep Center, Inc., 1127 Statler Office Building, Boston, Mass., 02116, telephone (617) 482-5233.

The Editors' Desks

Energy Technology
In this issue the *Review* concludes its special series on "Energy Technology to the Year 2000" which has been a feature of the first three numbers of Volume 74. We think it has been an important review of what the Editor has chosen to describe as "the ultimate confrontation" between technology and the limits of the earth's environment, and so we've arranged to collect the ten articles of the series in a paperback book. As this issue of the *Review* reaches readers, copies of "Energy Technology to the Year 2000" are ready in Cambridge at $1.95 each. Write to the Review at Room E19-430, M.I.T., Cambridge, Mass., 02139.

The Westinghouse Award
We record with pride that the articles by Victor K. McElheny published as "National Report" in Volume 74 of *Technology Review* have been awarded honorable mention in the annual competition for the Westinghouse Award in science writing. The Award, provided by the Westinghouse Educational Foundation and administered by the American Association for the Advancement of Science, is among the most prestigious for U.S. science writing; the citation was given to Mr. McElheny—who is Science Editor of the *Boston Globe*—during the annual meeting of the A.A.A.S. in Philadelphia at the end of December, 1971.

Talent Available
Readers of *Technology Review* may recall a series of "situations wanted" announcements under the heading "Talent Available" in the last issues of Volume 73; these were published to supplement the continuing efforts of the Institute's Alumni Placement Office to help bring new opportunities to the attention of M.I.T. graduates who might best capitalize on them.

That "Talent Available" no longer appears in the *Review* is not because there is a sudden dearth of graduates seeking new opportunities. It is instead because the Alumni Placement Office has found a faster and apparently more efficient means of matching jobs and talents. This takes the form of a periodical "Bulletin of Available Graduates," copies of which are available without charge to potential employers among the *Review's* readers. Write to the Editors, or directly to the Alumni Placement Office, Room E19-455, M.I.T., Cambridge, Mass. 02139.

Authors

Richard A. Carpenter
National Goals and Environmental Laws, pp. 58-63
studied organic chemistry at the University of Missouri and served with the Shell Oil Co., Midwest Research Institute, and Callery Chemical Co. (a subsidiary of Gulf Oil Corp.) before joining the Library of Congress in 1964. His paper is based on a presentation made at M.I.T. early in 1971.

Hoyt C. Hottel and Jack B. Howard
An Agenda for Energy, pp. 38-48
are colleagues in the M.I.T. Department of Chemical Engineering, with which Professor Hottel has been associated for 40 years and Professor Howard for six. The article in this issue makes it obvious that Professor Hottel's retirement from full-time faculty status in 1968 was only theoretical; he had previously been Carbon P. Dubbs Professor of Chemical Engineering, Director of the Fuels Research Laboratory, and—for many years—Chairman of M.I.T.'s Research Committee on Solar Energy. Professor Howard came to M.I.T. from Pennsylvania State University following completion of his Ph.D. The paper by Professors Hottel and Howard is based on the first chapter of their book, *New Energy Technology—Some Facts and Assessments,* just released by the M.I.T. Press; and that book, in turn, results from a study sponsored at M.I.T. by the National Science Foundation through Resources for the Future, Inc.

Lawrence M. Lidsky
The Quest for Fusion Power, pp. 10-21
has been concerned with plasma generation and acceleration (his Ph.D. thesis title, 1962) since coming to M.I.T. as a graduate student in 1958.

William W. Lowe
Creating Power Plants, pp. 22-30
has been a senior partner in Pickard, Lowe and Associates (consultants in the nuclear power field in Washington, D.C.) since 1956. He was a staff member at the Los Alamos Scientific Laboratory during World War II and later Chief of the Atomic Energy Commission's Nuclear Engineering Section at Hanford, Wash., and Chief Nuclear Engineer at the Bath Iron Works before entering consulting work. Mr. Lowe's paper in this issue of the *Review* is based on his presentation before an alumni seminar at M.I.T. in the spring of 1971.

Richard A. Rice
System Energy and Future Transportation, pp. 31-37
joined Carnegie-Mellon University two years ago as Visiting Professor in the

Transportation Research Institute after a 20-year career in the transportation industry which culminated with service as Director of Research for the Greyhound Corp. and as an independent consultant. His *Technology Review* article is a condensation of a paper prepared for the Energetics Division of the American Society of Mechanical Engineers.

Stewart W. Wilson
Interactive Lectures, pp. 50-57
began his experiments in technologically-aided learning as a graduate student at M.I.T. (Ph.D., 1967) in association with Edwin H. Land, President of Polaroid Corp. His work continues under the auspices of Polaroid, and many M.I.T. students continue to participate in his activities.

Letters

Welcome to Antediluvianism
The new format of Number 1 of Volume 74 is most attractive. Is the three-column, justified-margins typography only for special inserts?
Frederic W. Nordsiek
Coordinator of Research
St. Luke's Hospital Center
New York, N.Y.

Typographically, I know I belong to the antediluvian period, but . . . Welcome back, say I, to justified lines and serifs in the new *Technology Review!*
Corbin Gwaltney
Editor
Chronicle of Higher Education
Washington, D.C.

To Dr. Nordsiek, the answer: No.—Ed.

Up the Over-30 Generation
I presume your "First Line" (*pp. 3-4*) in the October/November issue was written to nettle your readers, and, I must say, you did a good job. However, this is not your primary function. Indeed, I resent such a callow, irresponsible, and arrogant article in such a prominent place in *Technology Review.* You surely do not believe that the twaddle about "the wisdom of the generation that is still under 30" is the thinking of M.I.T. men!

May I recommend some humility and some respect for the views of such a man as Mr. Pusey, even though over 30?
Paul Ivancich
Washington, D.C.

I resent your slur on the over-30 generation in the October/November issue of the Review. Since your wrath includes Harvard's President Emeritus you have at least put me in good company.

You talk about social conscience. I would guess that with that term you also include disavowal of discrimination. By what magic do you then come to the conclusion that the under-30 age group is superior to the rest of the citizenry?

Your clincher about the Urban Vehicle Design Competition symposium in Toronto is about as ill-chosen as proof of the wisdom of present-day youth as can be. Did you know that youth was ever thus? And ever will be, when you are defending your bread and butter by being a 50-year old faithful servant of whatever establishment is then keeping you?

What bothers me is not your personal attitude (you are entitled to your opinions even if they are discriminatory), but that you use a journal such as *Technology Review* to sound off in terms that are largely polemical. This reflects itself in much of what the journal prints. I resent its attitude and tone, as if engineers are dedicated to pollution, congestion, maintenance of poverty and uglification, at least those engineers who have passed the one score and ten demarcation line.

You might be well advised to address yourself to the eventual consequence of your line of thinking, namely that technology *per se* must be curbed or made to whither if whatever life style your philosophy implies is to become reality.
W. E. Meyer
State College, Pa.

The Editor hopes it self-evident to most Review *readers that he is not among those who, believing technology to be the source of most social ills, propose ending scientific and engineering change in order to solve the presumably associated problems. And he admits his observation of the "under-30" generation to have been largely limited to the academic community which centers at M.I.T.*

Your editorial in the October/November issue (*"The First Line," pp. 3-4*) sounds as if it were the product of some enthusiastic girl friend of a mechanical engineering student. The authentic thrill over the experience of actually seeing several hundred boys interested in what they were doing and, even more, the astonishment that they were willing to get their hands dirty in the process must surely have taken place in some young female bosom. It was rather sweet—but surely more suited to *Seventeen* than to *Technology Review.*
Marion R. Hart
Washington, D.C.

Science Review

Robert C. Cowen

The Promised Land of Fusion

Buoyed by several years' progress, researchers call the laboratory demonstration of controlled thermonuclear fusion a dream whose time has nearly come

(see "The Quest for Fusion Power," by Lawrence M. Lidsky, pp. 10-21). But if you go in for that kind of optimism your best reason for hope lies in the fact that fusion is at last finding a political constituency.

From the physics viewpoint, the question indeed is "when," not "whether." "When," depends more on money than on the experimenters' skills. Plasma physicists could putter on the brink of self-sustaining fusion for decades at their present level of effort. Fortunately, in America at least, environmentally-conscious voters are badgering Congress to give fusion workers what they need to get on faster with their job.

Senator John O. Pastore of Rhode Island says he and many of his colleagues are flooded with letters from people who see fusion as a potential power source that would be soft on the environment. They realize it would produce no hard-to-manage radioactive wastes as do fission power plants. It should cause marginally less heat pollution, too. Some voters and some members of Congress, misinformed as to the state of the art, suggest abandoning further fission power development in favor of an all-out effort on fusion.

Admitting this to be misguided, admitting the need to develop breeder reactors to fill the gap before fusion power could become commercial, how much more money will it take to push ahead with all deliberate speed? That, Senator Pastore says, is the question his constituents keep asking. At hearings of the Congressional Joint Committee on Atomic Energy in November, he and other committeemen zeroed in on this point.

Under the not-unwelcome pressure of such questioning, U.S. Atomic Energy Commission witnesses admitted their fusion program to be underfed but scientifically primed for takeoff. Roy W. Gould, who heads that program, said that, with enough new money, self-sustained fusion could well be running by this decade's end, if not before. That seems to be the consensus among fusion workers around the world. Given the greatly increased funding then needed to produce a working reactor, and lots of luck, the first demonstration fusion power plant might be ready by the mid-1990's, Dr. Gould estimated. He took care, though, to emphasize the unreliability of any timetable he might try to work out now for such a development. It involves a lot of unknowns.

Congress doesn't seem to mind this kind of uncertainty. The Joint Committee wanted a feel for the physicists' sense of where they stand, not a commitment as to long-range performance. Its members sense enough scientific promise—and feel enough pressure from back home—to abandon the indifference they have had toward fusion in recent years.

Closing the Gap
That promise grows out of striking progress made toward laboratory fusion. In his article elsewhere in this issue, Professor Lidsky describes the figure of merit developed by British physicist J. D. Lawson which attempts to say how dense a plasma must be and how long it must

stay together to produce at least as much energy as it consumes. Half a decade ago, laboratories seemed bogged down several orders of magnitude below that level. Today, as Professor Lidsky notes, many of the experiments have come within roughly a factor of a hundred.

Researchers won't close the gap between current achievements and Dr. Lawson's criteria with their present machines. Not even the newest ones are designed for this. They will refine our knowledge of plasma control. They will further test the scaling laws physicists are using to predict how their plasmas would behave in machines designed for break-even fusion. But we will need a new generation of experiments to try to attain this goal of a break-even reaction. This, Dr. Gould explains, is why physicists need more money now. It would not only enable them to pursue present research lines faster, but it would let them start construction of advanced machines in time to have them running before 1980.

At the Geneva Atoms for Peace Conference last September, retiring A.E.C. Chairman Glenn Seaborg said he thought fusion programs in all countries could easily use double their present budgets. Not wishing to be too specific on a matter his agency must negotiate with the budget planners, Dr. Gould cited an independent study. This suggests that the American program could effectively use an increase that doubled the present $33-million A.E.C. fusion budget over the next three years, then redoubled it over the ensuing three years.

The A.E.C. Division of Military Application also supports $8-million worth of research in laser-induced fusion. In this, highly energetic laser beams trigger the fusion reaction. While this work hints of long-term possibilities from the sidelines, the various forms of "magnetic bottles" described by Professor Lidsky now have the field. Thus a doubling of Dr. Gould's $33-million budget seems the kind of boost now talked about.

To judge from the attitudes of Joint Committee members, Congress seems disposed to give the A.E.C. whatever it thinks the fusion program can profitably absorb. Dr. Gould says the trouble may come in convincing the administration to raise fusion's priority a little. Yet, even there, the attitude seems to be changing. Presidential Science Adviser Edward E. David, Jr., says he's convinced it's time to put more money into fusion. So by this time next year, the somewhat emaciated look of America's fusion program may be disappearing, if it is not yet entirely gone.

What Will the Millions Buy?

In a field so fraught with hope yet bedeviled by physical limitations, it's important to remember just what a vigorous long-term fusion program might give us. Fusion promises power from a virtually inexhaustible fuel supply in a form least harmful to the environment, but even a completely successful development of deuterium-tritium (D-T) fusion could not truly fulfill that promise.

Deuterium accounts for about one atom in every 7,000 of earth's hydrogen. The half gram of deuterium in a gallon of water has the fusion energy equivalent of 300 gallons of gasoline. And it currently costs about four cents to extract that deuterium. Doubly heavy hydrogen truly is a superabundant fuel, probably adequate for millions of years. But tritium exists only to about one part in 10^{18} in the hydrogen of earth's waters. To use it for fusion, we will have to make it by irradiating lithium with neutrons in the fusion reactor itself. So lithium limits the fuel for fusion power. Some enthusiasts note that there's enough lithium in the upper kilometer of the crust to meet massively escalated energy needs for millions of years. Short of draconian measures to scalp the earth, however, much of this just won't be available. Dr. Gould puts reasonable supplies at about the level of today's reserves of fossil fuels, far short of the limitless fuel of the fusion vision.

D-T fusion won't offer the ultimate in environmental protection either. A neutron carries off most of the reaction's energy. Its energy, in turn, must be degraded to heat which can be transferred to a customary heat-cycle electric generator. Because it operates at higher temperatures than fission plants, this cycle may run at an efficiency of 50 to 55 per cent compared to the 35 to 40 per cent expected of a breeder reactor plant. While it will cause less heat pollution, the saving won't be dramatic.

Lithium conveniently can play a dual role of energy converter and tritium generator. Surrounding the reactor in a blanket, it will absorb escaping neutrons; as it does so the lithium will heat up and transform into tritium and helium. This conversion will also release heat to add 25 per cent to the reactor's output. Such a fusion reactor has only one ten-thousandth to a millionth the potential radioactive risk of a fission plant with its "hot" waste products. Yet a fusion reactor's radioactive tritium will have to be kept out of the environment. Both economics and safety considerations will force engineers to extraordinary efforts to contain and recover this valuable material. Unlike a fission plant, the fusion reactor cannot have a run-away chain reaction. But were it to lose cooling, the residual heat in the lithium blanket could melt containment walls. Loss of cooling to cryogenic magnets could induce powerful mechanical stresses. This will be the type of "maximum credible accident" with which the reactor designers must cope.

Only through the reaction by which deuterium fuses to deuterium (D-D) can we fully realize the fusion dream. This would indeed tap the practically inexhaustible fuel supply. The reaction yields 30 to 40 times the energy needed to induce fusion. This compares to a gain of 1,750 plus the 25 per cent bonus of lithium conversion for the D-T process. Yet with deuterium so abundant, the lower D-D yield doesn't seem a significant handicap. Furthermore, electrically charged particles carry away most of the D-D reaction energy. Probably their energy could be converted directly to electricity with high efficiency—a power source with relatively little radioactive by-product and minimal heat pollution.

With a Lawson criterion ten times higher than D-T fusion, requiring a higher ignition temperature while releasing less energy, the D-D process waits off-stage today. When Congress thinks of stepping up fusion research, it is D-T development everyone has in mind. Two decades hence, after hard technical slogging and sustained expense, we may well stand on the threshold of the fusion power era. Yet when we step over that threshold, we may find it leads only to a way station on the incredibly long road to the promised land.

Washington Report

Victor Cohn

"What About the Rights . . .?"

Has the time come for society to regulate science?

Consider this event. A mongoloid boy was born at Johns Hopkins University Hospital. Common enough—mongolism or Downs' syndrome is the most common cause of mental retardation. It occurs once in 600 births.

This baby also had an intestinal obstruction, however, that prevented him from receiving any nourishment. This could easily have been corrected by surgery, but the baby's parents refused permission.

They were told all the pertinent facts. Mongoloid children can lead happy, productive lives. They can learn simple jobs, though their IQ seldom tops 75. They are a focus of warmth and love in many families.

The parents nonetheless said "no" to the surgery, explaining, "Why burden society with a mongoloid child? Why not let God's will be done?"

The doctors consulted lawyers and judges, who said that no court would make the child a ward of the state—the only circumstance under which a judge could order the operation. It took 15 days for the baby to die, while, testified Dr. William Bartholme, senior assistant resident in pediatrics and doctor in charge, "I tried not to look at the baby, and when I did, I didn't want to touch it. The nurses were full of horror and disbelief. The father would call and ask, 'How are things?' meaning 'Did the baby die yet?' "

Dr. Robert E. Cooke, Pediatrician-in-Charge at Johns Hopkins, said of this case: "That's certainly child abuse. It gets on the border of murder."

An unusual case? Not so very. Bartholme said that at least four times in the last five years at this hospital alone, parents have similarly allowed mongoloid children to die by denying permission for surgery. He said that similar life-and-death decisions are made at least twice

a week by doctors at this hospital.

"Society," added Dr. Cooke, "seems awfully unwilling to help us out of a jam."

This bona fide example was presented in a 25-minute film during a compelling symposium on the ethics of medicine—and a search for solutions—sponsored last fall in Washington by the Joseph P. Kennedy Foundation.

Child Defenders?

Dr. Bartholme thought that "what we need is a group of people sophisticated enough in law, ethics, sociology and medicine to make this kind of decision," instead of leaving it to parents and doctors. (Johns Hopkins now has such an advisory group.)

Mrs. Sydney Callahan, psychologist and mother of several children, agreed. Parents should not have the right, she argued, to doom a child as though it were their "property." Each person should be thought of as "belonging" to the human species, with "child defenders," perhaps, to represent a baby versus his executioners.

But Dr. Renee Fox, Professor of Sociology at the University of Pennsylvania, said there are also dangers in the concept that we all must be our brother's—or child's—keeper. Severe emotional problems have been triggered by the request or demand of one member of a family that another sacrifice a kidney to save the first person's life. While some families have successfully accommodated a retarded child, others have been broken up. "What about the rights of our other children?"—this question was asked by the parents in the Johns Hopkins case.

Asked in Washington, such questions may be expected to generate political answers or responses. Sen. Walter F. Mondale (D-Minn.) and 16 senatorial colleagues have proposed a joint Congressional resolution to create a 15-member National Advisory Commission on Health, Science and Society, with a $1 million budget to make a two-year study of such dilemmas.

Mondale, a minister's son, has made such a proposal before, and in 1967 he even prompted a set of Senate hearings on the subject. They caused some, not much, comment. The largest notice was taken during the appearance of the glamorous Dr. Christiaan Barnard—his heart transplants were in their heyday. Barnard or not, the subject was soon forgotten.

Does This Sound Frightening?

One of these days, however, some new event—the birth of a test-tube baby? something else?—will take place someplace with the impact of an atom bomb, and all over the world everyone will say, "Why didn't we talk about such things?"

Biologist James D. Watson (of the double helix) passionately believes there should be "some form of international agreements" about whether or not to permit research leading to test-tube babies and cloned, biologically identical individuals "before the cat is totally out of the bag. If we do not think about the matter now," he maintains, "the possibility of our having a free choice will one day suddenly be gone."

Dr. Robert Edwards of Britain, a leading experimenter in test-tube conception, met Watson in debate in the Washington symposium, saying that the field is being investigated to help barren mothers have much-wanted children; that the "dogma that has entered biology from either communism or Christian sources has done nothing but harm"; and "we will do our transplants and go on with our work as we decide, not as anyone else decides."

Dr. Leon Kass of the staff of the National Academy of Sciences and Dr. Paul Ramsey, Princeton theologian, joined Watson in a call for a moratorium on such research. Dr. Howard Jones, Johns Hopkins obstetrician, compared such a call to the persecution of Galileo.

In any case, hazarded Dr. Anne McLaren of the University of Edinburgh, Scotland, babies produced in the test-tube and transplanted to mothers for their full growth and birth will be "a routine gynecological procedure within 20 years."

In that case, said Watson, "There are going to be a lot of mistakes. What are we going to do with the mistakes . . . You can only go ahead if you accept the necessity of infanticide."

Does this sound frightening?

The fact is that infanticide is already being widely practiced in American society—in elective abortions, which the majority of us favor, and in the growing medical use of amniocentesis. (Fetal cells are drawn from the amniotic fluid to be tested for chromosomal abnormalities, if the doctor suspects they may be present. Mongolism is one that can be found.) Amniocentesis is often followed by abortion to prevent birth of an abnormal baby.

We also widely tolerate:

☐ The incarceration—that's what it amounts to—of thousands of the retarded and mentally ill in institutions where life can only be called mean and degrading. There are good institutions, too, but society usually isn't willing to pay the bill for them.

☐ The sterilization of thousands of men and women, increasingly by voluntary choice to avoid producing babies, but also by law or judicial coercion or the decision of parents in the cases of many persons judged to be retarded or dangerous.

☐ The inoculation of retarded children (as at Willowbrook School on Staten Island, a New York state institution for the mentally retarded) with infectious hepatitis virus, deliberately infecting them. This study has been necessary over the past 15 years to develop a hepatitis vaccine. The children would all have been exposed to hepatitis virus anyway in this crowded little society, the experimenters explain. In every case, there was "informed consent" of the parents. Yet some critics believe that no one, not even a parent, has the right to consent to an experiment on anyone else.

And If We Stopped?

In many other medical experiments and investigative treatments today, informed consent is a dubious instrument. How, asks Dr. Henry Beecher of Harvard, can anyone give informed consent to a procedure whose result no one can know?

But how would we develop new vaccines and new ways of medicine without human experiments?

Has the time come for society to regulate science? The question is rhetorical. To a degree, we are regulating science already—by setting innumerable rules for the uses of drugs and practices of physicians; by allocating funds for research and development, slighting some fields and stressing others; by laws and taboos and social and ethical sanctions.

So far the talk about such matters has mainly been expert to expert. A Mondale commission might at least bring in the public.

National Report

Victor McElheny

A Turn Away from Hot-Gospeling?

Is it possible that our concern for the natural environment may be evolving away from hot-gospeling toward fact-seeking? Can it be that we are abandoning visions of apocalypse and beginning to assess, rationally, the environmental costs of a technologically-based, decent level of living for mankind?

In the past few months, sober assessments like the *Scientific American's* September issue on energy and power, and the Stockholm Study of Man's Impact on Climate, have appeared to offset slapdash analyses epitomized by Barry Commoner's new book, *The Closing Circle.* (The book argues that the U.S. needs to spend $600 billion junking that portion of its capital equipment now devoted to industries with an excessive potential for pollution. Commoner admits that this would use up most of our investment money for 25 years).

Several errors and excesses of the environmentalist movement—which seems to be based on a pessimism that originates in political mistakes and a dizzying pace of social change—have recently been exposed. Fashionable doom-crying has, it is apparent, little factual support.

It is becoming clearer than ever that the insecticide D.D.T. cannot be swiftly banned throughout the world without catastrophic retrogression of human health and food supply in poor countries, because malaria and agricultural pests will return. (Its use in the U.S. has steadily declined without legal penalties.)

It has been seen that phosphates in detergents, while imposing a burden on some lake environments, cannot be banned outright in a society dependent on machine washing without running medical risks with caustic soda substitutes. In the absence of an acceptable

substitute for phosphates (the supply of natural oil soap meets only 40 per cent of the world's demand for cleaning compounds), laws totally banning phosphates will have to be modified.

Meanwhile, serious research is just beginning into the contributions that phosphates may actually make to pollution problems in various environments, and into the relative costs of removing them from cleaning compounds or from sewage-treatment effluent (which contains human phosphates as well).

Thoughtful Studies of the Air . . .

Most of our air pollution laws are based not on fact but merely on the presumption of pollution's impact on health—chiefly on a handful of extreme incidents in which people actually died—and on the aesthetic unpleasantness of smog.

We do have some comparative studies from England of postmen (a control for occupation) showing that incidence of bronchial complaints in the country is less than in small towns and less in small towns than in big cities. But this sort of study needs to be done more widely and more thoroughly.

The 1970 Clean Air Amendments mandate a reduction in automobile emissions of 90 per cent from 1970 levels of carbon monoxide and hydrocarbons by 1975 and the same reductions in oxides of nitrogen by 1976. I believe there will be a huge eventual annoyance with the law, causing backlash relaxations of it or wholesale substitutions of simpler car-engines, as alternatives to the internal combustion engine become widely available.

Research into the assertion that carbon-dioxide or man-made particulates could alter global average temperatures up or down is taking the place of heated assertions that machine civilization is definitely on a collision course with nature. And there is research to be done.

There's been a considerable jump upward in stratospheric ozone in the past 10 years, when storms might well have breached the tropopause with an extra freight of oxides of nitrogen, from cars down on earth. But the arguments were pretty speculative. The late James McDonald was imaginative enough to see the possibility that water vapor from S.S.T. engines could thin out the radiation-shielding stratospheric belt of ozone. Harold Johnston and Michael McElroy saw that oxides of nitrogen from the same source could be even more important for this.

(The idea is abroad, ironically, that the environmentalists killed the S.S.T. Don't you believe it. The plane died for a lot of reasons, but basically it was uneconomic. Introducing a big fleet of American S.S.T.'s would probably have raised seat-mile costs for all airplane travelers, reversing a trend in commercial aviation since its beginning and robbing passengers of the already visible benefits from the wide-body jets. In today's political climate, you're not going to press on with subsidies for an airplane that will make it tougher for most voters to travel.)

. . . And of Nuclear Safety

Rational examination of costs and benefits is even breaking into the field of nuclear power plant safety, hitherto dominated by hobgoblin tales of massively increased incidence of cancer from radiation-releases and of heated lakes and oceans.

It is becoming apparent that some quite simple things can be done in nuclear power plants to reduce still further the quite minute chances of dangerous releases of radioactivity from regular nuclear plant operation or catastrophic accidents.

Richard Wilson, a Harvard physicist and the sort of man who asks for a dosage reading when he gets a personal x-ray, points this out. He thinks it's pretty silly for a state like Massachusetts, which requires teachers to get chest x-rays under certain circumstances, to be excessively worried about radiation risks from nuclear power plants—risks that are 1,000 times smaller.

Some extra backup equipment, he says, will cut down the dangers from a sudden loss of all coolant in the present generation of boiling and pressurized water reactors. Chambers can be built to hold stack gases or effluent water to allow more time for "decay" of tiny amounts of damaging radio-isotopes.

To cut down the small risks attendant on transporting "spent" fuel elements, each nuclear power plant could be equipped with an exact duplicate of its radiation-shielding pressure vessel to store the elements for longer than a few months, perhaps forever. And if it seems simpler to transport wastes to a few central places, then we can certainly force the turnpikes, the safest and fastest roads in the East, to abandon their idiotic restrictions against fuel element transport by truck. Do we really prefer sending the truck through towns?

Wilson's inquiries also are turning toward the mythology building up around the thermal burdens from power plants. Recently, under protest, a power company was forced into building cooling towers for a nuclear plant at Palisades, Mich., rather than sending the hot water into Lake Michigan.

At equal cost, Wilson argues, a pipe could be run three miles out on the lake bottom, penetrating a huge sink of water that never gets above 40°F., even in summer. This heat sink, starting at a depth of some 50 ft. and constituting most of Lake Michigan's volume, can handle the entire thermal burden from power plants on all shores of the lake from now to the year 2000 with, at most, an 0.2°F. temperature rise. The implications for nuclear plants on the boundary of a much larger heat sink, such as the Atlantic Ocean, are obvious.

To give environmentalists their due, many of these cooler assessments of environmental problems have been spurred by the hot-gospeling.

Optimism!

I accept absolutely the general principles that mankind ought to limit its numbers and minimize the drain on scarce resources and deal lovingly with the only biosphere, lithosphere, aquasphere and atmosphere that we have. But this does not specify unrealistic deadlines—nor does it argue for precipitate actions which will merely turn environmentalism into another craze, swiftly taken up and swiftly abandoned.

In the environmental field, we certainly could adopt Talleyrand's wise motto for diplomacy: not too much zeal.

A confident and rich civilization like ours, one which knows the benefits it has brought to people's souls and bodies, which knows that there will be a world here for our grandchildren, can do this. The tasks of civilization stretch out without limit into the future. To act feverishly as if there were not time left is probably to accelerate the final disasters that are feared, not ward them off. To act as if doom hangs over us is to bring doom closer.

Let me list some argumentative assertions about the environment that I can't prove.

☐ The battle with pollution is now and always has been inseparable from urban life. Without enormous victories, already won, urban life today would be impossible.

☐ Enormous power to regulate the environment has been bestowed on a new U.S. agency. It will take many years for all these powers to be fully exercised. The hair-pulling will be terrific. Let's settle down for the long haul. Ralph Nader has.

☐ There is obvious ignorance about quite elementary facts about the environment. The answer is a lot more research, with plenty of rigor and narrowness—*pace* Barry Commoner—from the physical sciences.

☐ It's quite useless to sell an environmental preservation program if it imposes a severe burden on people's material goals.

☐ The idea of an ever-escalating U.S. appetite for resources doesn't make much sense. I see it leveling off.

☐ The problem of squaring people's material wants with their concern for the environment would be a lot easier if the U.S. were doing a better job about guaranteeing everybody the main goods: housing, schooling, doctoring and transportation. Those are the four main ingredients of an equal chance in the society. Other societies are doing a better job about fair shares on these goods. England, Holland and Sweden come to mind.

☐ Hysteria about the environment can lead to inappropriate substitutions like caustic soda soaps for phosphate detergents. This could erode public awareness and concern for the environment.

☐ What's happening now is that a rich society, its appetite for material goods sated, is making decisions to spend a minor portion of its wealth and go to a minor amount of trouble in curing or preventing some assaults on the environment, often for aesthetic reasons. We certainly can afford to do so. Fearfulness is not a very good goad, confidence is.

☐ In the world ahead, we will have to take more care not to tread on each other's toes or spoil our patrimony of beauty for our children. In such a regulated world, our spirits will have more need, not less, for the refreshment of exploration of other planets.

Energy Technology to the Year 2000

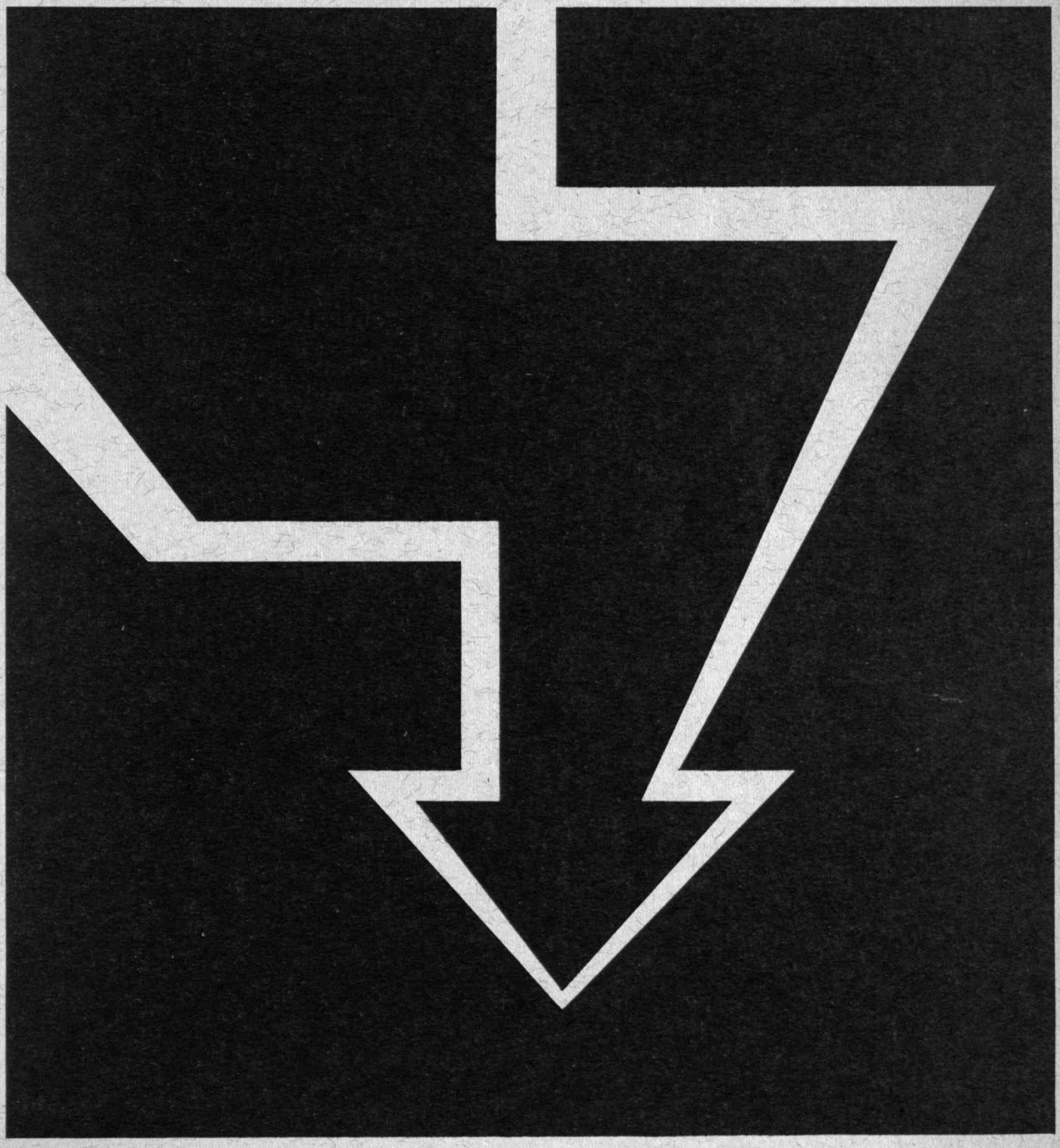
Part III: Energy Sources and Uses

Lawrence M. Lidsky on Fusion Power

William W. Lowe on Power Plant Construction

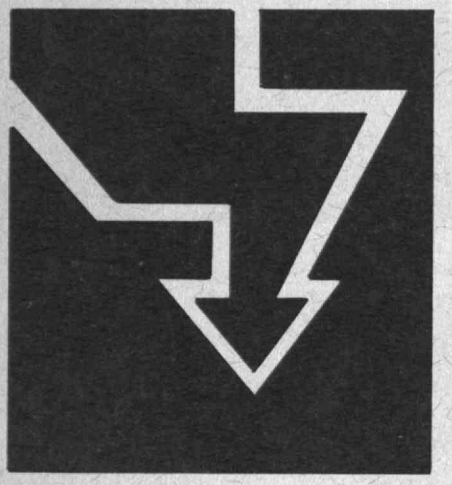
Richard A. Rice on Transportation Energy

Hoyt C. Hottel and Jack B. Howard on Assessment



by Lawrence M. Lidsky
Associate Professor of Nuclear Engineering, M.I.T.

The Quest for Fusion Power



The search for economical controlled fusion power is a scientific hunt for the Lost Dutchman Mine. Only a few true believers are *absolutely* certain that the goal exists, but the search takes place over interesting terrain and the rewards for success are overwhelming. In the case of fusion power, the potential long-term societal rewards are so enticing and the possibility of success so high that a major, truly international, research effort has developed over the last two decades. The United States has allocated over $400 million for research in controlled thermonuclear reactors (C.T.R.) to date and the U.S.S.R. more than twice that amount.

There seems little question that eventually either fusion energy or solar energy will be called upon to deliver the enormous quantities of "environmentally gentle" power that man will need. We should be able within five years to say whether significant amounts of energy can be obtained from controlled fusion within the next 20 to 30 years (before an irreversible commitment to an economy based on fission breeder reactors) or whether fusion power development will have to wait much longer until the technological and economic considerations are even more favorable then they are at this moment.

My plan in the following pages is to enumerate the potentialities of controlled fusion power, to describe the physical conditions we have designated as significant milestones, to describe experiments now or soon to be in operation, and to discuss the engineering problems of controlled fusion—which may be far more difficult of solution than the physics problems. Then, finally, I shall describe a possible scheme for relaxing both the physics and engineering constraints of an economical system.

The Potential of Fusion Power

The character of the atomic nucleus is such that the individual nuclear particles are most tightly bound in elements of intermediate atomic number. Thus when we seek energy we focus our attention on the more loosely assembled elements, releasing energy by splitting (fissioning) the heavy isotopes and proposing to do so by joining (fusing) the lighter ones. There is less energy release per fusion reaction than there is per fission reaction, but the reactants are more plentiful and easier to handle.

In general, a particular fusion reaction is interesting if the power produced can be large enough to offset the power consumed in generating and maintaining the reacting medium, and if the relevant rates can be large enough so that economically interesting regimes are accessible to modern technology.

There are, in fact, over 30 such reactions possible. The most interesting of the fusion reactions as possible routes to fusion energy are those which involve the heavy hydrogen isotopes deuterium (H_1^2 or D) and tritium (H_1^3 or T). These tend to have the largest fusion reaction probability (cross-section) at the lowest energies. Deuterium is an abundant, naturally occurring isotope in wide use now as D_2O in heavy-water-moderated reactors. Tritium is a radioactive isotope with a 12.3-year half-life (it emits an electron and decays to stable helium-3) that does not occur in nature.

The deuterium (D-D) reaction chain is

Fusion experiments are now reaching close to the elusive goals of temperature, density, and duration. But formidable engineering problems render the future still uncertain.

$D + D \rightarrow He^3 + n + 3.2$ Mev.
$D + D \rightarrow T + p + 4.0$ Mev.
$D + T \rightarrow He^4 + n + 17.6$ Mev
$D + He^3 \rightarrow He^4 + p + 18.3$ Mev.
$6D \rightarrow 2He^4 + 2p + 2n + 43.1$ Mev.

The first two equations represent the fact that the D-D reaction can follow either of two paths, producing tritium and one proton or helium-3 and one neutron, with equal probability. The products of the first two reactions form the fuel for the third and fourth reactions and are burned with additional deuterium. The net reaction consists of the conversion of six deuterium nuclei into two helium nuclei, two hydrogen nuclei, and two neutrons along with a net energy release of 43.1 Mev. The reaction products—helium, hydrogen, and neutrons—are patently harmless (in contrast to some of the myriad fission products in a fission reactor), and the neutrons may in fact be used in a variety of ways. One very simple possibility uses their absorption in sodium to produce an additional 25 Mev. per cycle. Therefore, the D-D reaction produces at least 7 Mev per deuterium atom (deuteron) and with absorption in sodium more than 10 Mev. per fuel atom.

The peak reaction rate coefficient of the D-D reaction is considerably less than that of the deuterium-tritium (D-T) reaction occurring within the D-D cycle; thus attention tends to focus on the latter. However, because tritium does not occur naturally, the reaction must be supplemented by one using lithium to reproduce the tritium fuel:

$D + T \rightarrow He^4 + n + 17.6$ Mev.
$n + Li^6 \rightarrow He^4 + T + 4.8$ Mev.
$D + Li^6 \rightarrow 2He^4 + 22.4$ Mev.

This reaction is tritium-regenerating and produces only helium as a reaction product.

The D-T reactor is technologically more complicated than the D-D reactor because of the need to facilitate the second reaction (which takes place outside the plasma) and because very energetic neutrons must be slowed down to allow the reaction with lithium to take place. Nonetheless, the conditions needed to achieve net power output are much less demanding than for the D-D fuel reactor.

Deuterium occurs naturally in seawater in a ratio such that one out of every 6,500 hydrogen atoms in H_2O is in fact the heavy isotope. Isotopic separation is relatively straightforward because the mass difference between H_2O and HDO exceeds 5 per cent. At 7 Mev./D, the energy attainable by fusion of all of the deuterium in a cubic meter of seawater is 12×10^{12} joules. This value is easier to visualize when compared to the energy content of a barrel of crude oil—6×10^9 joules. A cubic meter of seawater, then, corresponds to 2×10^3 bbl. of oil and a cubic kilometer to 2000×10^9 bbl. This last number is coincidentally nearly equal to recent estimates of the earth's total oil reserves. The oceanic volume is approximately 1.5×10^9 km^3, so there is more than one billion times the energy content of the world's oil reserve available to us through deuterium fusion. There are many interesting ways to illustrate the magnitude of this number (for example, it could support a world population of 7×10^9 people at 20 kw./capita—ten times the current U.S. rate—for 3×10^9 years), but such exercises are, in fact, just exercises. It is far simpler and just as accurate to say that *fusion of deuterium represents an essentially inexhaustable supply of energy.*

The D-T reaction will probably be exploited first, but its use will be limited by the availability of lithium. For such a light element, lithium turns out to be surprisingly rare. Recent estimates of lithium reserves place them at several times 10^7 metric tons, which limits the total energy release through the D-T-Li^6 cycle to approximately 5×10^{23} joules. The total energy content of the world's fossil fuel is 2.6×10^{23} joules.

It is easy to dispense with detailed computation of energy utilization trends here also. All reliable estimates of energy use conclude that we have sufficient fossil fuels to last for from 150 to 350 years. The lithium reserves will thus last for at least that long, and it is hard to believe that we will not have gained sufficient expertise in plasma physics during that time to enable us to tap the energy content of the D-D reaction.

Fusion Hazards

The end products of the fusion reaction—helium, hydrogen, and neutrons—can hardly be better chosen from the point of view of easing environmental pollution. It has even been proposed that the neutrons be used to clean the environment by transmuting certain particularly dangerous long-lived radioactive byproducts of fission reactors to harmless stable nuclei. There still remain two environmental hazards to be considered, however. There is the tritium that occurs as an intermediate reactant in both the D-D and D-T-Li^6 cycles, and there is the problem of radiological activation of the fission plant structure by neutron bombardment.

Tritium must be recycled in both

The end products of the fusion reaction are almost entirely benign. But some of the intermediates and the equipment in which they are used present a modest radiological hazard.

fusion chains considered above and is by no means a waste product. Instead, economical design for a fusion plant demands that the inventory of tritium in the plant complex be kept as small as possible and be circulated through the plasma reaction zone as rapidly as possible. Several studies of the inventory problem have resulted in estimates of the total inventory for a 5000-Mw(t). plant ranging from 2 to 10 kg. Most of the inventory is tritium dissolved in the circulating coolant and the metallic structure of the reactor. The larger value above corresponds to a radioactive burden in tritium of 10^8 curies (Ci), which is 40 per cent of the I^{131} activity predicted for a similarly-sized fast breeder reactor. However, the inventories cannot be compared on so simple a basis. The maximum permissible concentration of tritium in the environment is 2×10^{-13} Ci/cm^3, whereas the allowable concentration of iodine is 10^{-16} Ci/cm^3. The relative biological hazard attributable to escape of the volatile inventory in a fusion reactor is nearly four orders of magnitude smaller than in a comparably-sized fission reactor.

Because a single reactor is thus relatively safe from the standpoint of catastrophic tritium release, the tritium problem resolves itself to the minimization of leakage from all the reactors in a hypothetical fusion-power-based economy. For example, if all the world's population were using fusion-produced electricity at the current U.S. consumption rate (2 kw./capita), then an inventory leakage of 0.01 per cent per year would contribute less than 0.1 per cent increase to the naturally occurring radioactive burden. This level of containment is easily achieved.

The other radiological hazard, activation of the reactor structure itself, is less easily quantifiable. The afterheat and residual activity depend critically on the construction materials. In the worst case studied to date, that of a niobium structure, the decay power is 10 per cent and the activity is 100 per cent of the power and afterheat of comparable pressurized-water-reactor plants. In the best case studied to date, a vanadium structure, the decay power is 1 per cent and the activity only 0.1 per cent that of a comparable pressurized-water reactor plant. But, as in the case of tritium activity, a simple comparison is misleading; the activity in a fusion reactor is confined to the few activation products of a single material, whereas that of a fission reactor resides in a spectrum of fission products. Thus it appears that the structural activity of a fusion plant will certainly be no greater than and probably much less than that of a comparable fission plant.

Rejected waste heat has more recently become appreciated as a significant environmental burden imposed by electrical power generation. The ratio of energy rejected to the environment to energy transmitted as electrical power is a sensitive function of the power plant efficiency. An increase in efficiency from 32 per cent (typical of existing fission reactors) to 48 per cent (typical of proposed fusion reactor designs) would reduce the waste heat rejected to the environment by a factor of two. This difference exists in large measure because the fusion reactor, with separate reaction and heat removal zones, allows higher operating temperature than does the single-zone fission reactor. This return to the apparently primitive concept of "boiler and firebox" permits the design of liquid-metal-cooled systems with exit temperatures as high as 850° to 950°C.

Efficiencies much higher than 48 per cent can be contemplated for some fuel cycles by direct conversion of the high-energy charged reaction products to electricity, but the D-T reaction that will be the bulwark of the supply in the near future does not lend itself to direct conversion.

Scientific Feasibility

Fusion reactions can take place only when the nuclei of the fuel atoms are brought into close enough conjunction. The nuclei are, of course, positively charged and so repel each other. This repulsion is equivalent to an energy barrier which can be penetrated with reasonable efficiency only if the reacting nuclei have kinetic energy comparable to the barrier height. The level of kinetic energy required depends on the particular reaction and the desired reaction rate, but in general, plasmas of interest to C.T.R. have average energy per particle in excess of 5 kev.

A collection of particles with average energy 5 kev has an effective temperature of nearly 40 million degrees Kelvin (4×10^7°K). At these temperatures, the gas is completely dissociated into its constituent positively charged nuclei and free electrons. The electrical charge density is such that the behavior of the collection of particles is completely dominated by electrostatic and electromagnetic phenomena. Such a charge dominated collection of ionized matter is known as a plasma. Plasma at high temperatures cannot be confined by material walls but does respond to electromagnetic

forces. The central problem in the search for controlled fusion energy has been the design of a magnetic field configuration that would allow containment of plasma in more or less stable equilibrium.

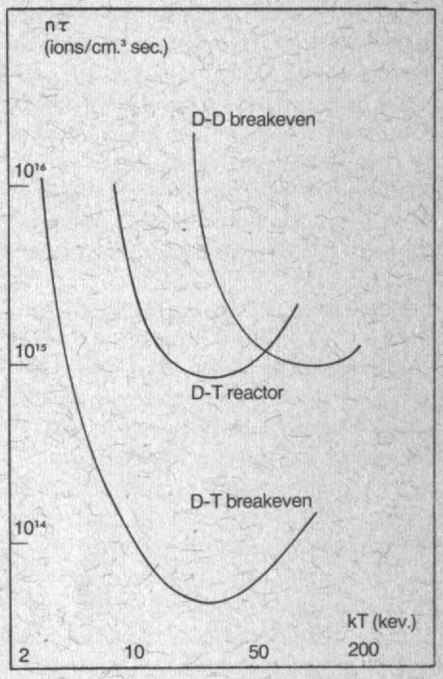
As in any gas of energetic particles, the ions and electrons in the plasma are continually undergoing collisions with each other. The collision rate is much higher than the fusion rate at reasonable energies, so the plasma particles in any magnetic trap undergo many collisions and rearrange their energy in a statistical fashion. Accordingly, there will be present in a magnetically confined plasma a spectrum of particle energies reaching up to very high values with a finite probability of fusion reactions occurring even in relatively low-temperature, low-density plasma. The occurrence of fusion reactions therefore furnishes no milestone in itself, and other more meaningful criteria must be sought. This is in contrast to the case of fission reactors, wherein the achievement of a multiplication coefficient greater than one is a clear dividing line between success and failure.

If the existence of fusion reactions in a contained plasma is not particularly noteworthy, the resultant neutrons do furnish a very useful means of describing the plasma energy distribution. These neutrons are surprisingly copious. For example, the Russian T-3 tokamak emits more than 10^{11} neutrons per second from its 500 ev plasma while the hotter, much denser Scylla IV plasma at Los Alamos Research Laboratory actually produces 40 to 50 watts of D-D fusion energy. If fueled with a D-T mixture, this device would generate nearly 200 kw. of fusion power for a three-microsecond pulse period.

What plasma regimes must be reached to yield usable power? The so-called "Lawson Criterion," one attempt to define the milestone, is developed by considering the energy balance per unit volume of plasma. One assumes that the plasma is brought together at temperature T, held there in equilibrium for time τ, and then allowed to disperse. The energy of this expanding plasma is recovered. If the operation is considered to occur in cyclic fashion, the energy balance equation becomes

$$3\,nkT + W_r\tau = \eta\epsilon(W_n\tau + W_r\tau + 3\,nkT)$$

where n is the density, W_r is the radiation emission per unit volume, and W_n is the fusion energy generation rate per unit volume. If η is the efficiency, then ϵ is the fraction of the power recovered that is needed to achieve the steady state. If $\epsilon = 1$, then all the energy is required just to keep the reaction going. If ϵ is less than one, then some power is left over which presumably can be considered as output. The left side of this equation represents the energy needed to assemble the plasma ions and electrons [$2 \cdot 3/2$ (nkT)] and maintain the plasma in the face of radiation losses. The right side represents the energy recovered, assuming that all forms of energy are handled with the same efficiency. When the proper functional forms are inserted for the radiation and fusion rates, the equation can be solved in terms of the $n\tau$ product, as shown in the adjacent diagram. The lowest -$n\gamma$ system is not necessarily the lowest cost system and, in fact, economic studies of toroidal reactors predict optimum operation for those devices at temperatures much closer to 10 kev. than the 25 kev. which corresponds to the $n\tau$ minimum.



The numerical values for the "Lawson Criterion," described in the text as the boundary at plasma regime, which might be expected to yield usable power, are here plotted for two values corresponding to a plasma system in which the thermal efficiency is 33 per cent and either all the energy is returned to the system ($\eta\epsilon = 0.33$) or only 10 per cent is utilized to maintain the plasma ($\eta\epsilon = 0.033$). From the plot it is clear that the minimum values of $n\tau$ are 4.5 x 10^{13} sec./cm.³ for power break-even and 8.3 x 10^{14} sec./cm.³ for a system of possible economic interest. (Data: Culham Lab. Report CLM-R85)

Once the confinement geometry is determined, one can separate the terms in the $n\tau$ product by an appeal to engineering judgment. In steady-state devices, the requirement that the overall energy density in the reactor be in the range of several watts per cm.³ leads to $n = 5 \times$

There is no single goal which guarantees the success of the fusion reaction. Rather, the issue is when, under any particular confinement scheme, will the process turn efficient?

10^{14}/cm.^{3} and $\tau = 0.5$ sec. But the fast "pinch" device would operate near $n = 5 \times 10^{16}$/cm.^{3}, $\tau = 10^{-2}$ sec. Yet another class of reactors, "stabilized mirrors," would necessarily operate far to the right of the minimum point; such reactors, if they are economical at all, will be so only if they utilize direct conversion.

There is clearly not a single goal whose attainment guarantees success but rather a set of goals corresponding to different confinement schemes. It is the object of controlled fusion researchers to predict on experimental and theoretical grounds which, if any, path is likely to reach its individual goal.

Success from the standpoint of plasma conditions alone is not sufficient, because the question of whether the particular confinement scheme is compatible with economic and engineering requirements remains to be answered. However, it is useful to remember as a touchstone that reasonable goals for a steady-state reactor are: plasma density $n = 5 \times 10^{14}$/cm.^{3}; pulse duration $\tau = 0.5$ sec.; and plasma temperature $T_i = 8$ to 10 kev. The experiments now being carried out are not aimed at these values, but rather at producing plasma conditions that allow all relevant interactions.

Experiments in Plasma Confinement

The experiments now in operation or just being completed are probably the last exploratory plasma *physics* devices that will be constructed for some years. Experiments now entering the design phase will be much more ambitious; indeed, they will aim at proof of "scientific feasibility" by generating plasma conditions so similar to those of a prototype reactor that the results can be extrapolated with reasonable confidence. The three concepts with the greatest potential are the tokamak, the stabilized mirror, and the theta pinch. These three devices are clearly differentiated from each other with respect to the dominant plasma processes, and they all scale differently with variations in plasma density, temperature, and, most importantly, with the size of the plasma.

There are many ways proposed to tap controlled fusion energy in addition to the ones described here. Most-discussed among these is laser-induced fusion, which requires no confinement whatever. In the simplest form of laser-induced fusion, a focused, very energetic laser beam is brought to bear on a small deuterium-tritium fuel pellet. If the laser pulse is energetic enough and the energy is delivered in a short enough time, the pellet can be heated to fusion temperatures. The fusion energy is released while the particle is in the process of rapid, uncontrolled expansion. The energy release is explosive, and there is a limit to the maximum amount of energy that can be released in a single pulse. When this limiting value is compared to the capital cost of the laser required to ignite the pellet, it soon appears that this system is further from economic feasibility than from scientific feasibility. Therefore, although this technique might be useful in some aspects of fusion research, it does not seem promising from the standpoint of power production.

Tokamaks

The T-3 device in operation at the Kurchatov Institute of Technology since 1962 is the prototypical example of toroidal confinement. The magnetic field lines in such closed geometries are constrained to follow toroidal surfaces, and the plasma particles (to first approximation) spiral along the field lines. But simple toroidal fields cannot confine a plasma in equilibrium, and one stabilizing scheme or another must be employed. The tokamaks, of which T-3 is an example, supply equilibrium by means of a large circulating current induced around the torus. This current also serves to heat the plasma by resistive (I^2R) heating.

The other commonly explored toroidal devices supply the required equilibrium by means of externally imposed twisted multipole magnetic fields. This class is represented by the stellarator design developed at the Princeton Plasma Physics Laboratory. Although one theoretically expects many equivalences between tokamaks and stellarators, the tokamaks to date have yielded far better results.

The induced plasma current in the tokamak generates a magnetic field that loops the minor axis of the torus; the field lines form helices along the toroidal surface, and the plasma must cross the lines to escape. It does so through the cumulative action of many random displacements caused by interparticle collisions, in effect, diffusing across the field lines and out of the system. Thermal energy is transported by much the same process.

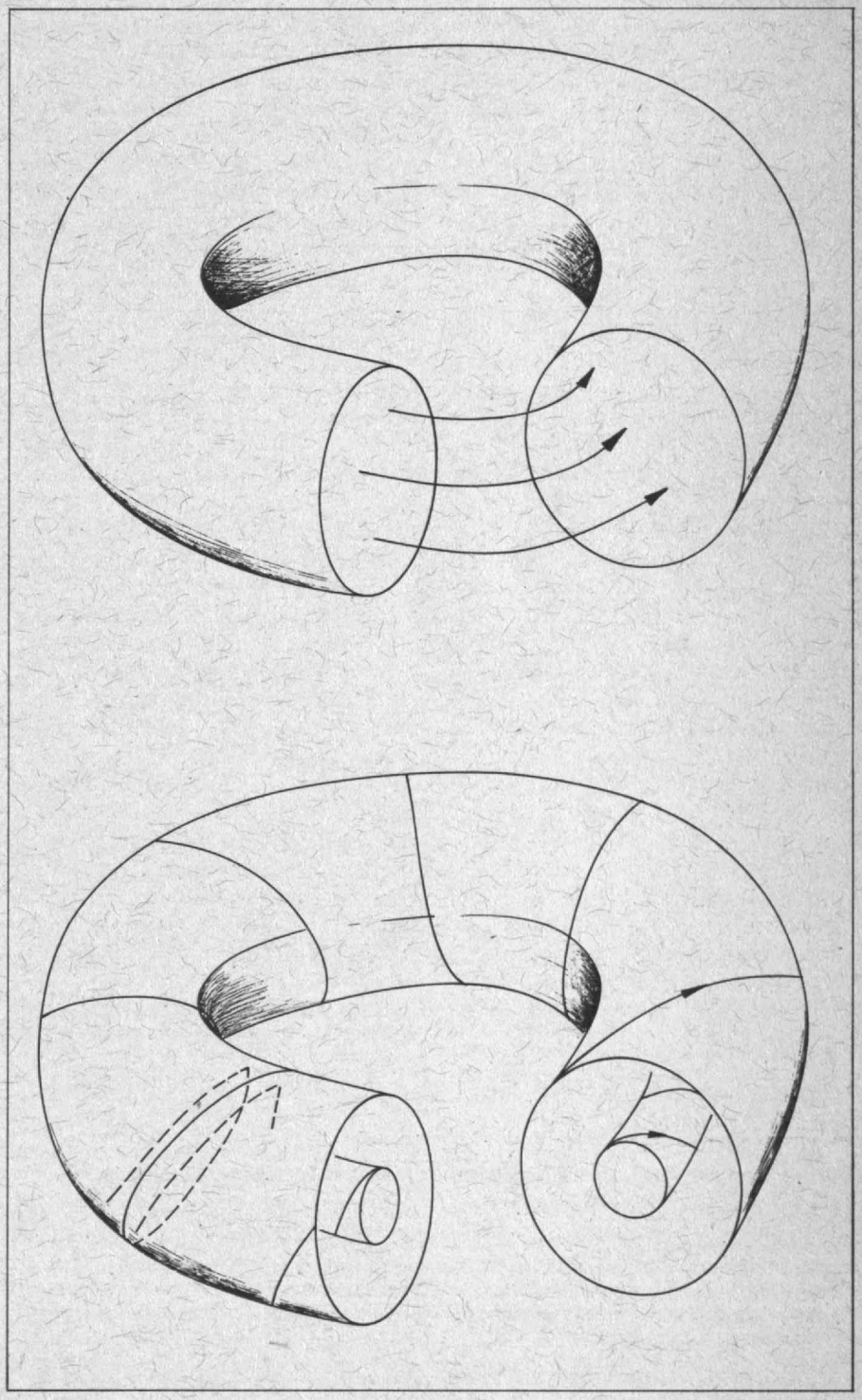
Particle orbits in toroidal fields are exceedingly complicated. Because of the spatially varying field and the acceleration experienced in moving along the curved field lines, the particles drift away from and return to the original magnetic field lines. These excursions are quite

large and the particle and energy diffusion are enhanced by large factors. The principal goal of the tokamak program has been to measure particle and energy confinement times under many conditions and to predict how these relationships may change as the size of the torus is increased. It is also apparent that the simple resistive heating of T-3 will not scale up to allow ignition of a toroidal reactor, and another major goal of the tokamak program is the development of an additional heating scheme.

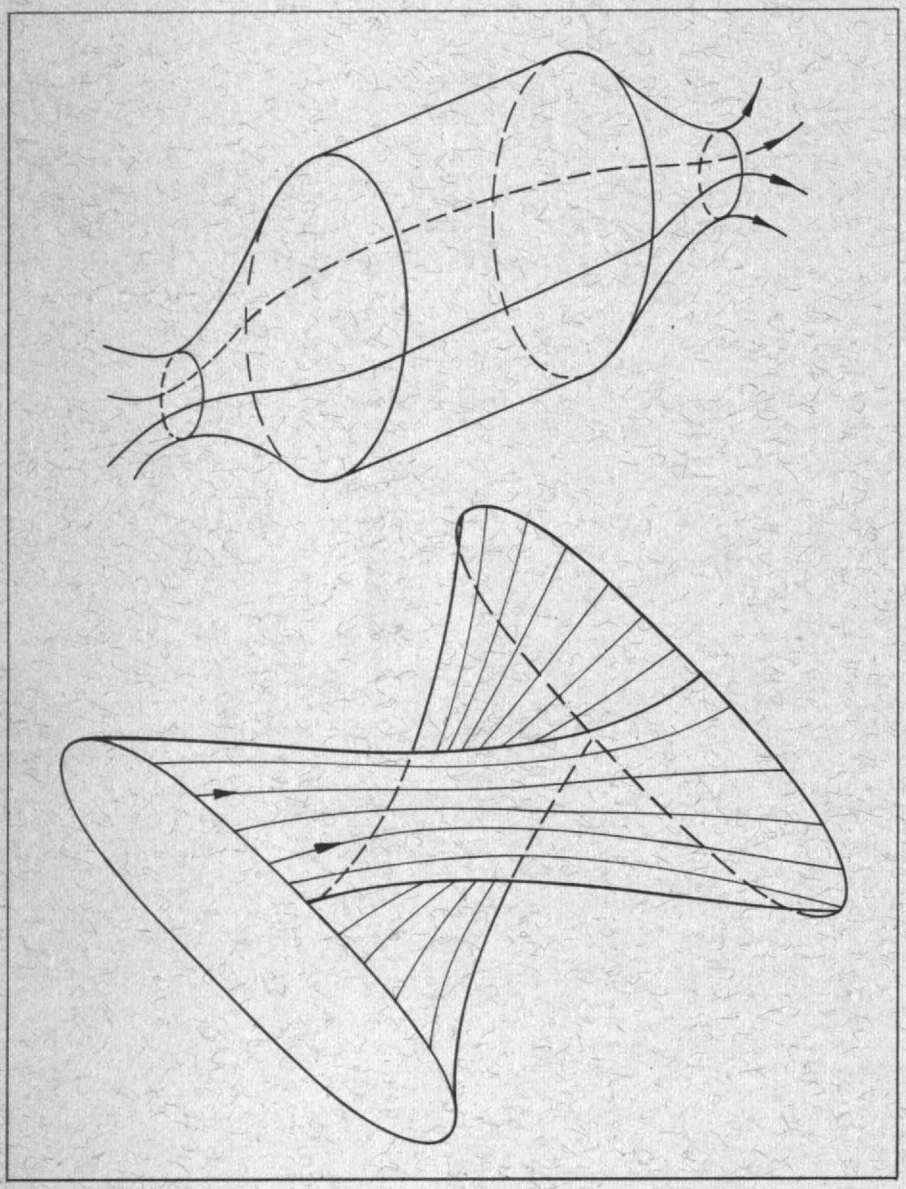
Stabilized Mirrors

If some way can be found to stop the charged particles of a plasma in their motion along the magnetic field lines, the magnetic field lines need not be closed within the plasma region and many problems associated with toroidal systems can be avoided. The "magnetic mirror" is based on a basically simple phenomenon: charged particles will reflect from a region of increasing magnetic field if their encounter with the field lines is close enough to perpendicular, and they will not be reflected if they are moving nearly parallel to the lines of force. "Mirror" devices take advantage of this by trapping the plasma in a bulge of the field, where the lines are spread. When the field increases, the lines reapproach each other and a reflecting region is formed.

The 2X mirror experiment at the Lawrence Radiation Laboratory uses a carefully shaped set of pulsed magnetic field coils. The plasma is



The magnetic field lines of the simple torus (top sketch) are complicated when a current-carrying plasma is added (below). The twisted field lines result in very complex particle orbits; a typical trajectory is shown by the dashed line.



The top diagram shows the basic concept of the "mirror" device: plasma is kept within the central region because the particles are repelled by the two areas of relatively greater magnetic field at the ends. In other words, where magnetic lines of force crowd together, a plasma-reflecting "mirror" is formed, and a pair of these mirrors contain the plasma.

However, plasma researchers soon found that the shape of the magnetic field around the central region—that is, bulging outward—caused the plasma to be unstable. The answer, now generally accepted, is to make the magnetic field lines bulge inward toward the plasma, as in the second diagram, which shows the central region of one type of "stabilized mirror" device.

injected and then trapped by these coils when the magnetic field is weak; it is subsequently heated by compression as the field grows with time. The containment region has the typical stabilized mirror shape and a volume of about 16 liters; the resulting plasma has density $n = 5 \times 10^{13}/cm.^3$, ion temperature $T_i = 8$ kev., and confinement time of 0.2 to 0.4 msec. This is a very interesting hot, dense plasma with confinement time only a factor of three to five below the theoretically expected value.

But the success of a laboratory-scale experiment does not guarantee success of a reactor concept based upon that experiment. There are very strong theoretical predictions that the mirror reactor will suffer increasingly severe plasma instabilities as the device is made larger. One could ordinarily tolerate a moderate level of instability or turbulence in a plasma because the effect is simply to increase to some extent the rate of particle loss from the trap. Unfortunately, the mirror reactor has very little margin for error.

Particles escaping from a toroidal reactor must move across magnetic field lines; but in a mirror device, it is required only that a collision send a particle in a direction nearly aligned with the magnetic field in order for it to escape. This can happen with reasonable probability in a single collision. The mirror device is thus inherently more leaky than the various closed-line systems, and this leakage manifests itself in particles streaming out the ends of the trap. If this escaping particle stream could be recaptured with high efficiency, the energy could be reinjected with minimal effect, and the development of electrostatic direct conversion was an effort to accom-

plish this purpose. Economic estimates show that this is sensible if the reactor performs up to its theoretical limit, but that even a small increase in the particle loss rate would doom the concept. The 2X experimental results, although not conclusive, appear to show that the mirror reactor does not perform quite up to its theoretical limit.

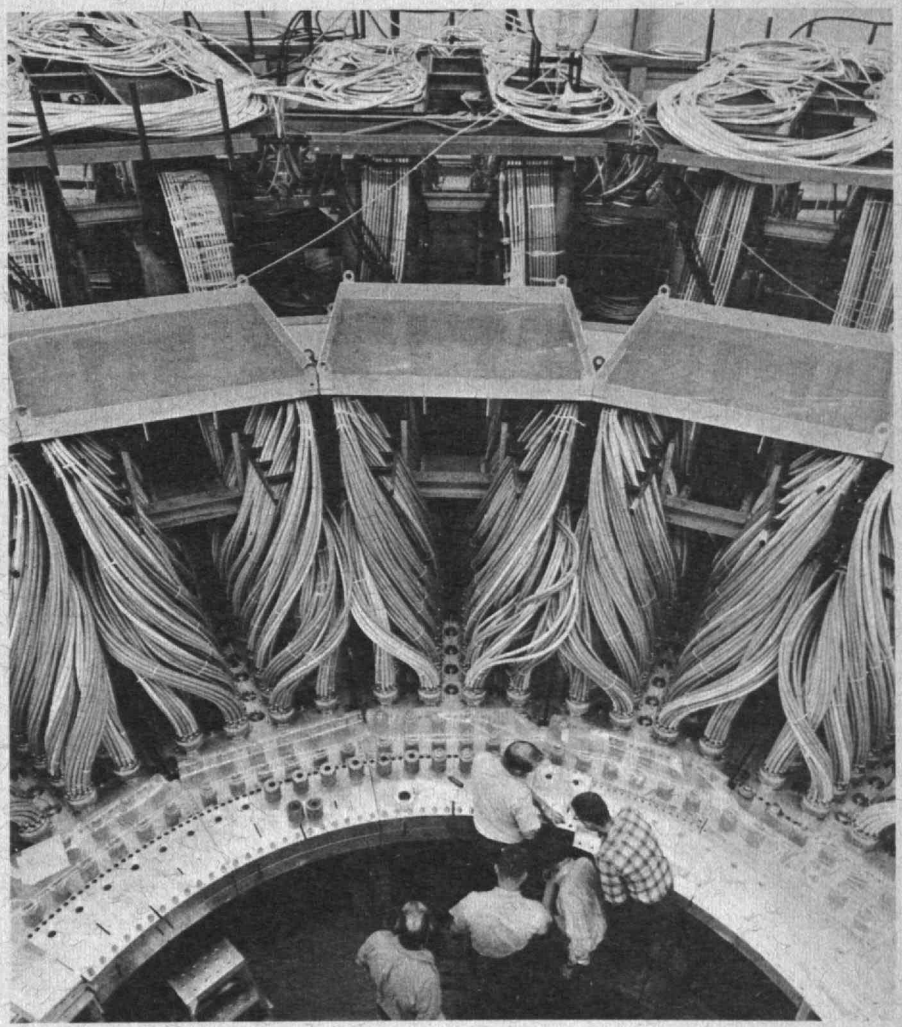
Theta Pinch—Scylla IV

The theta pinch experiments have been exploring yet another regime of plasma parameters—very high density. The object in these experiments is the extremely rapid compression of an existing low-density, low-temperature plasma. If the heating pulse is fast enough, there can follow a two-step process: the plasma is heated first by the shock wave generated by the rapidly rising field and then heated further by adiabatic compression as the field continues to grow more slowly in time.

The technology needed to perform these experiments is impressive indeed. Capacitors storing nearly a megajoule of energy at 50 kv. are discharged through hundreds of parallel paths (to reduce the inductance) into a massive single-turn compression coil to generate fields in excess of 100 kG. In the Scylla IV experiment, for example, the current rises to 8.6 million amperes in only 3.7 μsec. The resulting plasma has density $n = 5 \times 10^{16}/cm^3$ and ion temperature $T_i = 3.2$ kev. The plasma lifetime is very short, because the plasma particles simply stream out the ends of the device, though the plasma is in stable equilibrium occupying a thin cylinder in the center of the coil during its residence there.

Plasmas achieved in the theta pinch process are so hot and dense that the kinetic pressure is several hundreds of atmospheres and the plasma energy density very nearly equal to the magnetic field energy density. Plasma behavior under these conditions is not yet theoretically understood, and we are very dependent on experimental observations.

It is obvious that the way to avoid end losses in a theta pinch device is to close the ends upon themselves—to generate a toroidal theta pinch. This immediately reintroduces the toroidal loss-of-equilibrium problem,



This photograph illustrates the complexity of the experiment now underway at Los Alamos Laboratory to construct a toroidal theta pinch apparatus in which plasma may be confined and energized. The capacitor bank, not shown in the photograph, fills a separate very large room.

	Tokamak (T-3)	Mirror (2X)	Theta pinch (Scylla IV)	"Lawson Criterion"
Plasma density n/cm.^{3}	2×10^{13}	5×10^{13}	5×10^{16}	5×10^{14}
Maximum plasma temperature T_i (kev.)	0.6	8	3.2	10
Confinement time τ (msec.)	25	0.4	0.01	200

The fusion process is such that there is no sharp dividing line in a fusion reactor—as there is in a fission reactor—between "go" and "no go." Instead, there is simply the question of achieving a high enough steady-state fusion reaction rate to provide a sufficient excess of energy for power generation. This condition is roughly expressed by the so-called "Lawson Criterion." As the chart shows, it is now possible—at least in terms of density and temperature—to reach what the author calls plasmas at "the lower fringes of thermonuclear interest." He suggests that five more years of research will reveal whether the goal is in fact attainable soon.

but there are indications that this dilemma may be resolved through a proper combination of external fields which interact strongly with the high-density theta-pinch plasma.

The Atomic Energy Commission is funding a very large research program in toroidal theta-pinch apparatus (Scyllac) at the Los Alamos Laboratory. Because the experiment is so expensive, and because the theory is not very highly developed, an initial experiment is underway to provide "proof of principle." A 120° sector of the torus has been constructed and operated at reduced power. In this configuration, the stored energy is 3.5 megajoules and the peak current is 34.5 million amperes. Preliminary results (June, 1971) indicate that the external fields can, in fact, supply at least some degree of toroidal equilibrium.

The toroidal theta pinch may well provide the first proof that the appropriate "Lawson Criterion" can in fact be achieved, but this method is possibly incapable of being scaled up to an economical power-producing reactor. The economic difficulty arises because of the great capital cost of the requisite energy storage and because the pinch tends to produce power in bursts, with relatively long periods of time between bursts for cooling, pumping out impurities, and recharging the capacitor banks.

Experimental Summary

The accompanying table summarizes the plasma conditions achieved in the experiments described above and their comparison with the "Lawson Criterion" values. Several points are worthy of particular note. First, it is obvious that, at least in terms of density and temperature, it is possible *now* to reach the lower fringes of the plasma regimes of thermonuclear interest. Certainly we are close enough to these regimes so that almost all of the dangerous instabilities have manifested themselves. The Scylla IV containment time looks disconcertingly small, but this is inherent to the experiment and does not denote instability. In any event, the proper "Lawson Criterion" for such pinch-like devices calls for confinement time of only 2 to 10 msec.

The various routes to proof of scientific feasibility are clear. The tokamak concept must be tested at large radius to see if the plasma loss scales inversely with the square of the plasma radius. If it does, then the development of an appropriate energy input scheme would lead to the goal. Several very large tokamaks have been proposed, and many heating methods are being tried on smaller scale experiments.

As for the theta pinch, it must be closed upon itself. If external coils can provide equilibrium, then nothing further will be needed. The experiment now in progress at Los Alamos with a 120° section of the torus will go a long way to answering this question.

Mirror traps will have to be shown to be less prone to instability and enhanced losses than is currently predicted by theory. Experience shows that the opposite is usually true—that plasmas are in fact more unstable than expected. However, a mirror reactor would have a much larger ratio of plasma pressure to magnetic field pressure than the experiment carried out to date, and this regime is not amenable to theoretical analysis. Proponents of mirror reactor systems argue that appropriate experiments should be carried out in this regime. Such experiments would be extremely expensive, and there can be no certainty that they will be funded in the near future.

For both the tokamak and the toroidal pinch, five years should be sufficient time either to demonstrate scientific feasibility or to find that unsuspected obstacles stand in our way. The distance remaining to the goal is relatively short, so the unex-

The distance remaining to the goal of fusion is relatively small, so the unexpected has a small domain in which to lurk. But there remains the task of system engineering, the resolution of which is by no means certain.

pected has a small domain in which to lurk; the chances for success are therefore relatively good.

Engineering Problems of C.T.R.

Even if and when we discover how the "Lawson Criterion" can be fulfilled, there will remain the task of engineering large-scale, economic systems. And this is an issue of which the resolution is by no means certain.

We already know that in conventional power plants the greatest economic advantage can be obtained when materials are used near the limit of their capabilities. This will be true particularly of advanced power-producing schemes such as fast breeder reactors and controlled fusion reactors, because highly stressed mechanical elements allow the designer to relax requirements on the reactor core. In the case of the fusion reactor, for example, higher heat loads at the interface between plasma and container would permit a lower ratio of container-to-plasma volume and thereby lower the unit capital cost of the plant.

There are important problem areas common to fission and fusion reactors. These include radiation damage, limiting heat fluxes and temperatures, and induced radioactive afterheat. The first of these will apparently be far more severe in fusion reactors; the other two will be comparatively less severe than in fission plants. (Other engineering problems of the fusion reactor which are specific to the particular design —tokamak, for example—will be ignored here because they are somewhat less fundamental and appear solvable by extensions of existing techniques.)

Many engineering features, are surprisingly insensitive to details of the nature of the plasma. Consider, for a concrete example, a steady-state, D-T-fueled toroidal reactor, and recall that 80 per cent of the energy release is in 14.1 Mev. neutrons. Elementary economic analyses of steady-state reactors show that the magnetic field must be generated by superconducting magnetic coils, because the power loss in normally-conducting materials is prohibitively high. On this basis one arrives very quickly at a conceptual model of the main features of the cylindrical blanket that surrounds the plasma column.

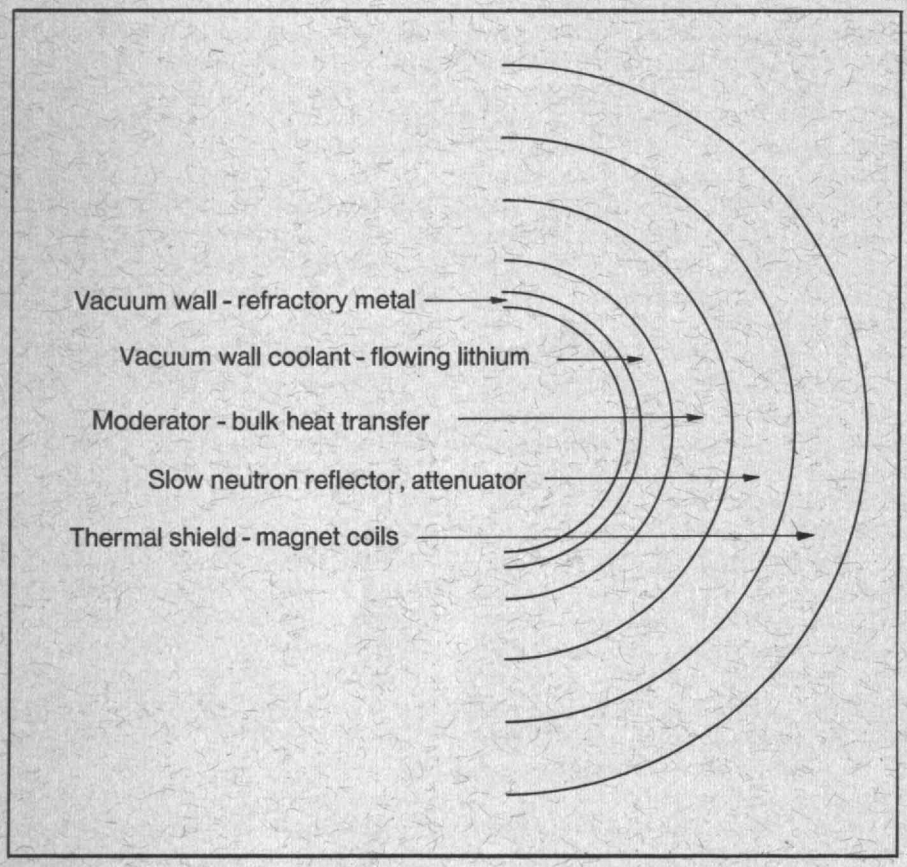
The shell immediately surrounding the plasma must be of a refractory material to withstand the enormous flux of neutrons and short-wavelength electromagnetic radiation. This first wall must be very well cooled because—although most of the energy passes through this wall —an appreciable quantity of energy (the amount depending on the thickness of the wall) will be deposited within it and must be removed. On the other hand, a well-chosen material will generate appreciable amounts of additional neutrons, and the final design thickness will be a compromise between neutron production and allowable thermal loads. The shell surrounding this one—the first wall coolant—will be devoted primarily to heat removal from the first wall, but proper material choice will allow neutron and tritium generation in this region. The third and subsequent shells will moderate the neutron flux, remove the neutron energy in the form of heat, generate tritium by the Li^6 absorption reaction, and shield the magnetic field coils from the neutron and gamma ray flux.

The bulk of the energy removal from the blanket occurs in the thermalization and tritium generation region, but it is not as highly stressed as the first wall because of the cylindrical geometry of the system. The radial size of the blanket will be determined by the need to use with high efficiency every neutron emitted from the plasma, because at least one triton must be generated for each neutron emitted. Almost all blanket designs call for a radial thickness of 1 to 1.5 meters. This requirement impinges, through economic considerations, on the plasma physics, because the plasma radial size must be comparable to the blanket thickness or the power density of the system will be far too low.

Another strong constraint on the blanket thickness will be the necessity for using superconducting coils to generate the intense magnetic fields required. The coils operate near 4.2°K, but the energy deposited in them by neutrons and gamma radiation must be rejected at the temperature of the environment. When the thermodynamic Carnot factor and refrigeration efficiencies are considered, it becomes clear that only .0001 of the total reactor power can be allowed to reach the magnetic field coils. Thus, it appears impossible to use a blanket much smaller in radial extent than 1.5 meters.

Several groups (most notably at Oak Ridge National Laboratory and the United Kingdom's Culham Laboratory) have published the results of careful studies of conceptually reasonable blankets.

A. Fraas and D. Steiner of the Oak Ridge National Laboratory have shown that published intensive studies show that the problem of material damage by radiation will be more severe for fusion reactors



Cross-sectional structure of a hypothetical fusion power generator. Around the plasma there must be: coils to create the magnetic field which contains the plasma; coolant fluids to remove the heat generated; and radiation shielding. In the lithium (in this particular scheme), a nuclear reaction generates tritium and neutrons which are needed by the plasma in order to maintain the fusion reaction.

than for fission breeder reactors. The radiation damage effects, particularly swelling, are the limiting design considerations in breeder reactors. They may not be quite so important in fusion reactors because fission reactor cores are characterized by a large number of narrow cooling passages, while the blankets of fusion reactors can be designed with much larger coolant passages and mechanical tolerances. Although the swelling is certainly a major concern, there is a paucity of information regarding the effect of very high doses of 14-Mev. neutrons and no experimental facility is presently capable of measuring the effect. A key piece of engineering design data is simply unknown.

There is yet another problem inherent in the blanket design. The ideal material for use as heat transfer medium for the first wall is liquid lithium, because of its low vapor pressure at high operating temperatures and because lithium in this location takes full advantage of the high-energy neutrons for the Li^7 reaction. However, this means that an electrically conducting fluid must be moved through the steady magnetic field. One consequence of this is that considerable power must be available for pumping the coolant, and the cooling passages must be designed to minimize cross-field flow. A possibly more important consequence arises because the magnetic field suppresses the turbulence in the fluid and so reduces the heat transfer coefficient. Experiments are now in progress to measure the magnitude of this effect, but the analysis is not complete.

To summarize: many severe engineering problems, radiation damage chief among them, will limit the allowable heat flux at the blanket-plasma interface. The heat flux will determine the capital cost per unit of power, and low heat flux might possibly raise the cost to economically uninteresting levels. It may well take longer to determine the allowable engineering parameters than it will take to prove the "scientific feasibility" of fusion power. It is in belated realization of this that the A.E.C. is now starting large-scale funding of engineering research in problems of C.T.R.

Fission-Fusion Symbiosis

Those who attempt to assess the prospects of generating appreciable fusion power in the near future generally assume that the D-T-Li^6 cycle will be used. Recall that this cycle demands that the tritium be regenerated by various reactions with

We think we have found the Lost Dutchman Mine. But the hoped-for proof "scientific feasibility" will be needed to conclusively demonstrate its existence; and we are still unsure if exploiting the mine will make economic sense.

lithium in the blanket. Engineering studies of such tritium regenerating blankets have been carried out at many laboratories, and all of them show that it is a relatively simple matter to breed more tritium than is needed. A typical calculation, for example, shows that 1.3 tritons are generated for each neutron incident upon the blanket. In other words, the cycle becomes $D + Li^6 \rightarrow 2He^4 + 22.4$ Mev. $+ 0.3n$.

The neutron excess offers many intriguing possibilities. Of course, some of the excess neutrons will be needed to generate more tritium than is consumed in the reactor to allow the start-up of additional fusion plants. However, the reaction rate per unit of power is very high, and a neutron excess will clearly be available. This raises the intriguing question of how to exploit the resulting change from a "neutron-poor" to a "neutron-rich" economy.

One of the more provocative possibilities involves the absorption of the excess neutrons in either thorium-232 or uranium-238 to yield the fissionable isotopes uranium-233 or plutonium-239. Each of the fissionable nuclei that might be produced would represent at least 200 Mev. when burned in a fission reactor and could result in a net yield of more than 1,000 Mev. in a reactor with reasonably high conversion efficiency. Thus the excess neutrons from a fusion reactor could in fact represent far more energy than is produced by fusion reactions in the core itself. Indeed, a new "generalized Lawson Criterion" can be defined in terms of this symbiotic fission-fusion scheme. Fusion reactors that would not be economically interesting by themselves become economically viable in the symbiotic system. From the point of view of plasma physics, the $n\tau$ curves are shifted to the lower values of the product.

In general, the technological characteristics of fast fission reactors and conceptually reasonable fusion reactors form a complementary set. Fission reactors produce low-cost power at high power density, but they can be made to breed only at the price of compromising either safety or economics. Fusion reactors may well have low power density and concomitant high costs; but because of the neutron excess, they will breed new fuel at a prodigious rate. A combined system in which fuel is bred primarily in the fusion reactor and power generated primarily in the fission reactor achieves properties attainable by neither alone—economical, safe power generation with almost arbitrarily short doubling times. Furthermore, the loosening of design constraints would allow other benefits. For example, to ease problems of thermal pollution, the fission reactor could be optimized for safe high-temperature operation, and any resulting penalty in neutron economy could be compensated for in the fusion portion of the system. In terms of such overall considerations, the distance between "scientific feasibility" and "economic feasibility" is materially reduced.

Finding the Lost Dutchman Mine

The focus of the search for controlled fusion power has changed during the past several years. We have learned to confine plasmas at high temperature and high density for long periods of time. The densities and temperatures have nearly attained values of reactor interest, and energy confinement times have been stretched by many orders of magnitude from the several microseconds typical of the early, unstable devices to several tens of milliseconds in tokamaks.

The question of whether we achieve fusion power in the near future is now cast into quantitative rather than qualitative terms. The full evaluation will depend at least as much on engineering limitations of the system as it will on the plasma physics, but there is some hope for relaxing these constraints in combined fission-fusion systems.

In terms of the original metaphor, we think we have found the Lost Dutchman Mine. The hoped-for proof of "scientific feasibility" will be needed to demonstrate its existence conclusively; and we are still unsure if exploiting the mine will make economic sense. Although this is the subject of intense physics and engineering research—and far from solution—it seems highly unlikely that so glorious a resource as the vast oceans full of clean-burning deuterium will remain unavailable for use.

Suggested Readings

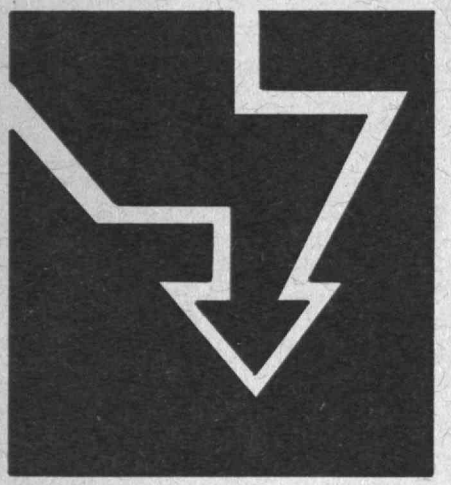
William C. Gough and B. J. Eastlund, "Prospects of Fusion Power," *Scientific American*, February, 1971, pp. 50-64.

Herman Postma, "Engineering and Environmental Aspects of Fusion Power Reactors," *Nuclear News*, April, 1971, pp. 57-62.

David J. Rose, "Controlled Nuclear Fusion: Status and Outlook," *Science*, May 21, 1971, pp. 797-808.

William W. Lowe
Pickard, Lowe and Associates, Inc.
Washington, D.C.

Creating Power Plants: The Costs of Controlling Technology



Large power plants—particularly nuclear power plants—are an example of a whole class of man's tools, including electronic information systems, computers, modern weapons, chemical plants, vehicles and genetic modification techniques, which, en masse, make many thinking men nervous and sometimes discouraged about the future of mankind.

This nervousness and discouragement centers around the question of whether or not these powerful new tools and techniques, which are now proliferating exponentially, can be used to benefit man or whether they must contribute in the long run to his dehumanization, enslavement, or destruction. Many who acknowledge that science and technology have been of great benefit in the past nevertheless share this uneasiness.

The question goes deeper than whether public health and safety or physical survival can be assured, or whether the physical efficiency of society can be increased or maintained, or whether the environment can be respected. It extends to the matter of how technology impels social change, and of whether individuals in a technological society can be as free as they have been in other cultures, or whether in some more or less subtle sense they will become subjects of, perhaps slaves to, the needs and capabilities of their tools. Ultimately, the question involves the matter of what goals are to be sought, what conditions enhance individual growth and happiness. But, even in technologically experienced cultures, there seems to be little agreement as to what these conditions and corollary goals for guiding technological change should be, and there is even less agreement as to what methods of guidance are possible and efficacious.

The absence of adequate goals and methods represents an insufficient response—potentially disastrous and pervasive—to a massive and fast-growing cultural challenge, which can only be met successfully with great effort. If the challenge is thus recognized and an adequate effort made, such major disasters as nuclear war, overpopulation, or broad genetic change can be avoided. But the outcome is by no means certain. It is in this context that the process of creating large nuclear power plants constitutes an interesting and instructive case history which to some degree illuminates the matter of whether man's tools can in the long run be of benefit to him, whether disaster must be a prerequisite for developing adequate guidance for technological change and what the cost of guidance may be.

Nuclear power plants are truly new and very powerful mega-machines. They are being injected rapidly on a very large scale into highly developed technological societies, under controls designed to implement objectives deliberately specified in advance. For the U.S., the Atomic Energy Act of 1954 defined these goals as the encouragement of widespread development and use of atomic energy for peaceful purposes consistent with public health and safety. These original goals are being broadened—for example, by the Environmental Policy Act of 1969, prospectively by a rapid evolution in various proposed power plant siting bills, and in effect by the way existing laws are administered. Whether these broadened goals and methods for achieving them are adequate remains to be judged; that the result remains in doubt is made

The apparent success of the processes for guiding nuclear power development towards preselected goals has not been generally applauded—rather the reverse. It is important to find out why.

obvious by the current public debate over nuclear power plant siting and safety, and by the occasional shortages of power caused in part by delays related to regulating processes.

The Nuclear Power Industry in the U.S.

The goal of widespread participation as set down in the Atomic Energy Act is being fulfilled. More than 30 nuclear units of 1,000-Mw. capacity or larger are either being built or are under design in the United States, and an equivalent number are in planning stages. Each one involves a capital expenditure of from $250 to $500 million. Some 60 or more smaller nuclear units, many in the 500-to-800-Mw. class, are being constructed or operated. About half the new U.S. power capacity ordered in 1967 was nuclear, and after a slack period in 1968, 1969, and 1970, the fraction is increasing again. Nuclear plants may represent half of the total capacity ordered in 1971.

The total investment in operating nuclear electric power plants in the U.S. will be about $20 billion by 1975 and by 1980 may reach $50 billion—essentially all committed within the past 10 years. In addition, there is a large supporting industrial structure to mine, process and enrich uranium, to manufacture components and fuel, to reprocess spent fuel, to predict and measure environmental effects, and to develop new types of nuclear energy generators.

The goal of protecting the public health and safety is also being met. There has not been a single radiation fatality resulting from the operation of licensed power plants, nor is there any evidence of off-site exposure in excess of regulatory limits. Despite public criticism, there appears to be no credible evidence that these limits have been inappropriate, especially when viewed in the context of how they have been applied.

Type of exposure	Annual total population exposure (Man-rad/yr.)	Annual maximum individual exposure (rad/yr.)
From gaseous effluents:*		
Gamma	3.6	3.8×10^{-4}
Beta	16.3	1.3×10^{-3}
Inhalation	0.09	9.0×10^{-6}
Ingestion of milk	23.2	6.2×10^{-3}
From liquid effluents:*		
Ingestion of water	0.55	5.5×10^{-6}
Ingestion of fish	0.00041	4.1×10^{-7}
From natural radiation:	500,000	.133

*Actual future exposure is expected to be less.

There is no evidence that thus far in the development of nuclear-fueled power generating capacity in the U.S. has there been off-site exposure to radioactivity in excess of regulatory limits. And, writes the author, "there is no credible evidence that these limits have been inappropriate when viewed in the context of how they have been applied." The table shows typical current estimates of radiation exposure within a 50-mile radius of a nuclear power unit; actual future exposure is expected to be less.

Societal Control of Nuclear Power Plants

The apparent success of the societal process for guiding nuclear power development towards preselected goals has not been generally applauded—rather the reverse. And it is important to find out why.

Not long ago at an Atomic Licensing and Safety Board (A.S.L.B.) hearing—a public hearing which is required before a permit to construct a nuclear power plant can be issued—a young person opposed to the issuance was heard to say that if construction could not be prevented by legal means the plant would be blown up. Whether this

	1,000-Mw. coal-fired plant	1,000-Mw. nuclear plant
Net fuel consumed (per year)	2.5 million tons	1 ton uranium (130 tons U_3O_8)*
Onsite fuel inventory	0.5 million tons	80 to 140 tons uranium (500 tons U_3O_8)*
Solid waste produced (per year)	25,000 tons ash	50 tons uranium (total 2,500 tons of cask shipments)
Gaseous waste produced (per year)	9 million tons CO_2, 0.1 million tons SO_2-NO_x, 0.1 million tons fly ash, 0.005 curies (radium and thorium)	3 to 300,000 curies (mostly xenon and krypton)
Liquid waste produced	—	3 to 3,000 curies H^3, 0.1 to 10 curies of other materials
Heat produced:		
To stack	300 thermal Mw.	—
To condenser	1,300 thermal Mw.	2,100 thermal Mw.
Total	1,600 thermal Mw.	2,100 thermal Mw.
Water consumed:		
If heated 10°F.	2,000 cu.ft./sec.	3,300 cu.ft./sec.
If evaporated	26 cu.ft./sec.	42 cu.ft./sec.

*The equivalent net annual requirement for U_3O_8 needed to replace the fuel consumed or to make new fuel.

In terms of the fuel consumed and the waste effluents produced, fossil-fueled and nuclear-fueled electric generating plants are almost totally different. A good site for one type of plant may be an inefficient site for the other, and the problem of coordinating these characteristics with social and ecological constraints promises nothing but more effort and frustration for the energy industry in the next decades. The table compares the fuel used and effluents produced annually by 1,000-Mw. coal and nuclear units.

was a serious statement or not, the kind of concern it implied must go beyond the issues before the Board, which were primarily radiation safety and environmental effects, since blowing up a plant is not the way to increase safety or control environmental effects.

This incident is probably an aggravated symptom of what appears to be a widespread uneasiness as to where burgeoning technology of all kinds is leading us and whether the establishment is doing an adequate job of handling it. Such uneasiness in the face of unanswered philosophical questions about technology in general is not news, but the significance of its practical effect on the process of creating nuclear power plants is less well known. An enormous amount of public discussion, much of it negative and in many cases uninformed, has been focused on the nuclear power industry. The political consequences have led to a great elaboration and tightening of governmental requirements and reviews and a consequent large increase in the burden carried by managers and technologists in the industry and in the government agencies involved.

Some of the debate has been in public hearings, which have cost millions of dollars directly and which in some cases have resulted in large financial losses for power companies and ultimately for power consumers by delaying the use of plants which have already been built. These hearings have provided an avenue—not open in most other technologies—for people who are uneasy about technology in general to try to slow down one specific aspect of it. Further, because of the large financial losses involved in delays, the power companies have often settled for requested modifications in their plants whether there was technical justification or not.

Thus an attack really intended against technology in general, mis-

trusting its capability within existing systems to benefit mankind, has become in effect a very heavy attack on nuclear power in the U.S., because regulatory procedures make nuclear power the one technology most open to attack, and probably also because it is new. This is ironical, because nuclear power has been from its very beginning, among all major technologies, the one most closely controlled and successfully guided toward preselected goals. Thus, one current cost of successful guidance of technological change, or at least of pioneering in such guidance, appears to be the delay and criticism incident to making open public debate a part of the process.

The Mechanisms for Technological Control

There are at least five fundamental mechanisms for controlling technological development by law without resorting to totalitarianism or depending primarily on mythology, religion, or an uncodified public ethic. These are:

☐ Modification of economic incentives through tort liabilities, taxes and patent systems;

☐ Alteration of organizational structures in defined sectors (e.g., government ownership of selected technological industries);

☐ Definition of private rights (e.g., the right to a healthful environment);

☐ Enactment of laws forbidding the use or limiting the number and nature of certain machines or techniques;

☐ Regulation by government agency, under laws defining at least to some extent that agency's powers, methods, and goals.

The nuclear power sector has primarily been controlled by the last of these methods. Although laws have been proposed in several states and in the U.S. Congress to declare a moratorium on nuclear power plant construction (the fourth method listed), none has passed. Inverse price structures (the more you use the more you pay per unit of consumption) have been discussed as a way of limiting power demand, but have not been applied.

The basic legal framework for societal control of nuclear power plants is currently embodied in four federal laws. The Atomic Energy Act of 1954, as amended, deals with radiation control, antitrust matters and national defense and security. The National Environmental Policy Act of 1969 deals with environmental effects in general and requires federal agencies to prepare a detailed statement on specified environmental considerations in connection with every major federal action significantly affecting the quality of the environment. The Water Quality Improvement Act of 1970 includes requirements for the control of thermal effects, as does the Refuse Act of 1899 as recently rejuvenated. There are also numerous state laws, some requirements by regional authorities, and some local ordinances.

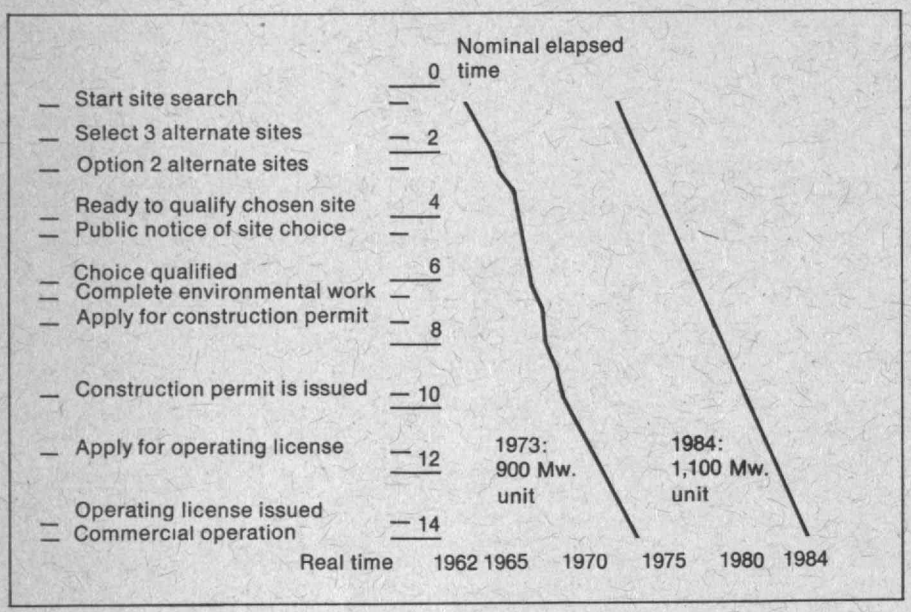
In addition to existing statutes, proposed laws concerning power plant siting are now before the U.S. Congress and several state legislatures. In general they would require a determination, a number of years prior to the start of construction, that a proposed power plant site is suitable.

The current complexity of statutory requirements is underlain by a great and growing mass of detailed federal, regional, and state regulations and an even more detailed implementation of them in accordance with safety guides, codes, standards, precedents, and—one sometimes suspects—sheer caprice.

The Means of Societal Control

A typical sequence of activities required to satisfy the Atomic Energy Act and related regulations for the construction of a nuclear power facility begins with the preparation by an applicant of a Preliminary Safety Analysis Report, a document which occupies from two to five feet of shelf space and which contains a detailed design description and radiation safety analysis. This report must accompany the application for a construction permit. It is reviewed by the A.E.C.'s Division of Reactor Licensing, and detailed agreements —concerning design criteria, design bases, and predicted routine and off-standard radiation effects—are developed on the basis of this document. These detailed agreements often take two or more man-years of A.E.C. staff time and five to ten man-years on the part of the applicant and his designers and advisers (in addition to the effort required to develop the safety analysis report itself).

The resulting record, along with the A.E.C. staff conclusions and recommendations, is next reviewed by the Advisory Committee on Reactor Safeguards. If the committee finds that the plant can be built on the basis described without undue risk to public health and safety, it issues a letter to that effect to the Atomic Energy Commission. Then, if the A.E.C. concurs, after suitable notice, a public hearing is convened before an Atomic Safety and Licensing Board (A.S.L.B.) whose findings will result in the issuance or denial



Because the size of nuclear plants is increasing and because controls on their design, construction, and operation are more pervasive, the time required to plan, build, and put into operation a nuclear plant is increasing. Planning for a typical 900-Mw. nuclear plant which may now be under construction began early in 1963, and the plant may begin commercial operation in 1973, but planning must already have started for a 1,100-Mw. unit if it is to be completed and in operation by the end of 1984. Thus what used to take 9½ years is stretching to 13½ years—an interval which may well exceed our ability to foresee the requirements which the new plant must fulfill.

by A.E.C. of a construction permit. Any qualified intervenor can become a party to the A.S.L.B. proceedings to contest issuance. Such contests are occurring increasingly often, and they can turn hearings into *de novo* reviews of radiation safety and environmental matters. The whole process from initial application to issuance currently takes 20 to 30 months.

One prerequisite to the issuance of a construction permit (under the Water Quality Act of 1970) is certification by the state involved that it will issue the equivalent of a water use permit. This certifies to the state's understanding that thermal and other discharges to waterways will be limited in accordance with state requirements based on federal guidelines. Another prerequisite is that the applicant submit an assessment of all significant environmental effects of the plant, stating why the particular site and technology was chosen in preference to alternatives. On the basis of this environmental report, the Atomic Energy Commission prepares a detailed environmental statement incorporating comments from the 10 to 20 federal agencies concerned. In a recent landmark decision (Calvert Cliffs Coordinating Committee Inc., *et al* vs U.S. A.E.C., July, 1971) the U.S. Court of Appeals for the District of Columbia Circuit criticised the A.E.C. and required it to make a substantive, independent and public review of benefits versus environmental costs in each licensing case, including consideration of alternatives, irrespective of the fact that other state or federal agencies have certified that their own standards are satisfied. As a consequence, it is likely that the work necessary to describe and analyse all environmental effects of a plant and to justify the choices made among alternatives (e.g. alternative sites, methods of power generation, etc.) will be greater than any heretofore required for radiation safety control. Since all of these matters are to be considered in public hearings subject to intervention and lengthy argument, there is more than a small possibility that long delays in licensing are in prospect.

Design and construction activities must be carried out according to a detailed A.E.C.-approved quality assurance program. These activities are audited by the A.E.C. Division of Compliance to assure conformance with the quality assurance program and with the plans and objectives specified in the safety analysis report.

To obtain a license to operate a completed facility, a process similar to that for obtaining a construction permit is repeated. It involves a Final Safety Analysis Report which is more detailed and definitive than the preliminary one and a revised environmental impact analysis.

An A.S.L.B. hearing is not mandatory, although one is held if there is an intervenor, if the A.E.C. decides there should be a hearing, or if the applicant requests one. The practice under the present system is to submit an application for an operating license 24 to 30 months prior

The system for controlling nuclear power development is cumbersome, and at times inconsistent and confusing.... It is not easy to regulate closely a new technology which is developing very fast.

to expected commercial operation. When finally granted, the operating license contains an appended technical specification which summarizes, typically in some 100 pages, the technical conditions governing plant operation. There must also be detailed written operating and emergency procedures consistent with the technical specifications. The people who manipulate the controls of the unit must have operator's licenses, for which they must undergo training for several years and then qualify on the specific plant involved by passing an examination conducted by the A.E.C.

After the plant is in operation, any incidents which have safety implications must be analysed and reported to the A.E.C., and if certain limits are exceeded the plant must be shut down until the matter is cleared with the A.E.C. Changes in technical specifications have to be approved by the A.E.C., as do changes to the plant which could affect its safety; the latter must be made under quality-assurance procedures similar to those used in the original construction. Operations and modifications are, once again, audited by the A.E.C. Division of Compliance.

Control: Effective, Cumbersome, Confusing

Many difficulties are inherent in the present system for societal control of nuclear power plants, and these combine to raise serious obstacles in the process of creating power plants on time. A basic difficulty is that there remain uncertainty and confusion as to how the newest federal statutes (the National Environmental Policy and Water Quality Acts) are to be interpreted, what the relationship is between them, and how they relate to existing or contemplated state laws and regulations and to the prerogatives of regional and local authorities. Some of these uncertainties and interrelations have been, or will become, matters of litigation. Some parts of the process are antiquated and irrational. For example, it is absurd to consider at a public hearing, as is done now, the issue of whether or not an already-constructed plant fits properly into the environment, unless there is a clear case of potential damage not previously evaluated.

Another inherent difficulty is that regulations and standards change with time, and there is a strong tendency on the part of regulators to force *ex post facto* conformance to new rules and standards adopted or proposed during the process of design and construction or after actual operations commence, even in cases where improvements in safety or environmental effects are marginal. Obviously, this can greatly complicate design and construction.

Although the system for controlling nuclear power plants does indeed work, it is cumbersome and at times inconsistent and confusing. But one should not attribute a balance of virtue or fault to either the legislators, the regulators, the courts, or the creators of power plants. The difficulties may only illustrate that it is not easy to regulate closely a new technology which is developing very fast. The important thing is to improve the definition of goals and the methodology of regulation, so that the process becomes less subject to delay, confusion and unproductive manipulation.

Planning for Power Capacity

Having outlined the current methodology for regulating nuclear power development, it may be useful to examine what the process means in practice.

The creation of a power plant commences when an individual electric power utility organization, usually in coordination with its neighbors (e.g., a regional power pool) includes it in a 10- or 20-year plan for meeting projected demands for power capacity and energy production. For a number of reasons, this planning process has become very complex. First, demand for power has increased exponentially at 7 to 12 per cent per year (depending on the particular region), sometimes faster than predicted. Second, in the past 20 years there has been a revolution in the technology and scale of power generation which alone has imposed a major burden on many organizations. Third, state, regional, and federal regulations have become so complex, demanding, and sometimes confusing as to seriously disturb the planning and even the construction process, as already noted. Fourth, serious delays in building large plants have occurred due to problems with labor and construction management. Fifth, the slowness of the rate-making processes whereby power prices can be changed to respond to increased costs, together with the very large requirement for construction capital, have created difficult and in some cases crucial financial problems and have forced some organizations to defer building needed capacity. Sixth, the need to correct defects in engineering and construction have sometimes led to construction delays and to reduced availability of newly-constructed plants after start-up.

All of these effects and related uncertainties make it very difficult to

	Actual:	Estimated:	
	1965-1970	1970-1980	1980-1990
Number of 1,000-Mw. units needed per year:			
Fossil-fueled	15	15	16
Nuclear-fueled	2	14	35
Number of nuclear sites needed per year	2	7	17
Thousands of miles of transmission lines needed per year:			
<200 kv.		5	5
>200 kv.		5	5

In the next two decades, the U.S. will continue to build fossil-fueled generating capacity at the rate experienced since 1965. But nuclear-fueled plant construction will increase rapidly, and between 1980 and 1990 sites for 17 new 1,000-Mw. nuclear units will be needed each year—a prodigious requirement in terms of any current experience. Routes for transmission systems will also be in keen demand. The table shows the new construction achieved in the continental U.S. in 1965-70 and that forecast for the next two decades.

predict when capacity can be realized and at what cost. Consequently, for every new plant now being planned it is necessary to pursue alternative development sequences in parallel; and this must continue even after construction starts, in order to assure that—one way or another—sufficient capacity is developed on time.

The planning process, subject to the difficulties described, is characterized in the accompanying chart (p. 26), which shows the major steps needed to create nuclear power capacity. For a 900-Mw. nuclear unit scheduled for operation in about 1973, the search for a site commenced in 1964, nearly 10 years before the projected date of commercial operation. But for an 1100-Mw. nuclear unit scheduled for commercial operation in 1984, site search—at least in our opinion—should commence in 1971, more than 13 years before the expected issuance of the commercial operation license. Longer time is required for constructing the larger unit, but the most important factor in the changing "lead time" is the proposed federal requirement that power plant sites be qualified five years in advance of the start of construction, at least nine years before commercial operation.

Thus the whole process of planning, building, and starting-up a major nuclear power unit may consume in the order of one third of the total working career of the persons involved. The same time span is likely to cover three to five changes in political administrations, which have a great deal to say about what is acceptable and what is not.

The lengthening lead time poses several difficulties. First, judgments and determinations as to the economic and environmental appropriateness of a given location, or of acceptable technical alternatives for development of the same site, become less accurate for a more distant future. Second, changes in rules and regulations over time may negate initial choices. Third, particularly in the absence of generally accepted goals, the ground rules tend to change with changes of political administration, sometimes in unwarranted and unpredictable ways.

Since lead times are different for different types of power plants (nuclear plants, for example, require the longest lead time), the planner may tend to prefer—or even be forced, if the planning process slips out of control—to use those types of plants with shorter lead times. This is one reason why the market for gas turbines has been large recently: alternatives are blocked as time runs out, power demand is growing, and the only choice left is to use units which can be built with short lead times—but which may not be the most economical or beneficial in the long run.

Siting of Nuclear Power Plants

A very large number of generating units and sites for power stations will be required annually in the United States in the next decade; the accompanying chart illustrates the magnitude and importance of the job which has to be done. For example, it is estimated that some 70 new sites for nuclear power plants will be needed in the 1970's.

When one sets out to find a nuclear power plant site, one may often want it to be suitable also for large fossil units in order to keep the options open. Since nuclear plants require longer lead time, they will still

Statutes now under consideration propose that several alternative sites for a given power capacity be qualified five years before start of construction. Qualification of each will cost several million dollars.

control the timing of the development steps.

The major considerations in finding a proper site for a large power plant are related to environmental effects and economics. The environmental effects in turn are related to the quantity and kinds of wastes, including radiation from nuclear plants and waste energy to be disposed of as heat to the environment. Two accompanying charts show the amount of waste energy to be expected for large nuclear and fossil units, and the radiation exposure attributable to routine releases from a nuclear unit of a particular design. As can be seen, exposure from a nuclear power plant—even under present regulations—is estimated to be a small fraction of natural exposure. Recently-proposed regulations would lower exposure from nuclear power plants even further. In addition, in the case of nuclear power plants it is necessary to consider potential risks from accidents which could release radioactive materials—a subject to which I shall return.

Various power plant siting statutes now under consideration propose that several alternative sites for a given power capacity increment be qualified five years prior to start of construction. We cannot know at this stage how much environmental analysis will be needed or appropriate to qualify a site, but it is almost inevitable that the rights to acquire land plus the environmental and preliminary design studies needed for such qualification will involve several million dollars. The process will require preliminary meteorological, hydrological, geological, foundation, seismic and demographic investigations of each potential site; and these studies will require analysis with respect to potential environmental effects from both routine operations and potential accidents. The plant must be designed to safely contend with floods, earthquakes, tornadoes, hurricanes, sabotage, and sometimes airplane crashes, and accidental off-site explosions. Designs are therefore required to withstand events which are severe and very unlikely—that is to say, have mean reoccurrence intervals of less than once in 10,000 years. The criteria for design and the design targets (e.g. flood heights) have to be established at the stage of site qualification, well before construction starts.

Purchasing and Detailed Design

Present practice is to buy a nuclear steam supply system from a single supplier (there are five of them in the U.S. for the types of plants now being built) and at the same time to purchase a matching turbine generator and at least a first load of nuclear fuel. To come close to making equitable contracts requires skilled and experienced management, including both legal and technical capability. Because this capability has not been sufficient on either side of the table in the past, the nuclear power industry has not yet stabilized in the sense of learning how to make equitable contracts which properly provide for future contingencies, including changes in regulations.

Detailed design commences at the time the principal suppliers are chosen, with two interrelated efforts: establishing the design concepts and criteria to be reflected in the Preliminary Safety Analysis Report (P.S.A.R.) and producing sufficient foundation drawings so that construction can commence on schedule.

Safety analyses now incorporated in the application for a license are founded primarily on value judgments of how safe is safe enough, and in the end they will always have to be that. But there is a developing trend toward use of more quantitative analysis of risk coupled with a growing tendency to set, at least informally, quantitative limits on risk. For example, one could in principle set a standard of acceptability in terms of the probabilities of accidents of various magnitudes—one could specify, in other words, the permissible probability for a given risk to people with smaller chances for larger effects (*see* Technology Review *for July/August, 1969, pp. 73-74*). If this could be done, then—given a power-plant design—each of the postulated normal and abnormal transients and accidents could be analyzed so as to relate the probability of its occurrence to the severity of the consequences. If, then, the combination of probability and severity fell below an agreed limit, the safety of the plant would be considered adequate.

While one can develop a fairly good estimate of the consequences of various hypothetical transients and accidents, it is difficult at this stage to make responsible quantitative estimates of the probabilities of occurrence. But such estimates, even when limited to qualitative considerations, are often fruitful because they help us keep in perspective what is important and what is not. The nuclear power industry seems to be ahead of most others in developing such methods and in setting safety goals at a very low risk level.

Then there is the unavoidable necessity to balance safety against economics—to evolve what might be termed an acceptable risk-versus-

benefit ratio. While it seems distasteful to balance benefits—particularly as measured in economic terms—against risks to people, this is in fact what is done now tacitly, by judgment, in any field of engineering and in many other fields such as medicine and perhaps even foreign policy. One does this also in everyday life, although one usually does not think very deeply about it.

With nuclear power plants the cost of changing risk levels can be high. For example, in one case, $30 million was spent in order to lower the risk of a particular type of incident which was already judged to be low (in the region of one chance in one million per year) to an even lower probability of occurrence, judged to be approximately one chance in 100 million per year.

(Incidentally, this discussion of design, in emphasizing some things which relate to societal control and public safety, leaves aside the very large amount of first-class engineering capability, and the very large magnitude and complexity of the engineering effort, required to design a nuclear power plant.)

Construction and Operation

For the past five years the construction of large nuclear power plants in the United States has been out of control, in the sense that initial cost estimates and schedules developed at the start of most of these projects have not been realized by large margins.

In some cases this has come about because the organizations involved were not sufficiently experienced to handle design and construction projects of such large magnitude and complexity within original estimates. The difficulties have sometimes developed because of unanticipated labor inefficiency and strikes, shortages of skilled workers, and the imposition of very stringent quality assurance programs and regulatory requirements—the implications of which were not clearly understood or defined at the outset. These effects can conspire together against the power developer: for example, on one particular plant now under construction the net effect of these problems is a delay of a year and a half in commercial operation and cost increases of about $100 million, compared to the original targets.

But the industry is learning, and the potential benefits of nuclear power (especially low fuel costs) have, up to now, still outweighed the difficulties in most cases.

About two years before a plant is scheduled for operation at power, a detailed plan—subject to influence by the A.E.C. and others—must be developed for pre-operational testing and qualification of the many systems and sub-systems involved. Only when this complex series of pre-operational tests has been completed can an operating license be issued. When this is done and the reactor is placed in operation, another set of integrated tests is carried out at low and high power to verify that its performance, particularly with respect to nuclear safety, is satisfactory.

Operating experience indicates that large nuclear power plants will perform well once specific problems which arise during initial operation are corrected. There have been occasional initial operating difficulties such as unexpected cracks in pressure parts, leaks in fuel cladding and steam generators, vibration in pumps and pipes, and unanticipated plant-staff workloads, for example in connection with the processing of radioactive wastes and the surveillance of instrumentation and safety equipment.

The Need for Guidance

These long and sometimes tedious processes which have evolved to guide the development of nuclear power in the U.S. have been successful up to now, if one judges by the current status of the technology compared with the goals defined for it in the Atomic Energy Act of 1954. Although there are increasing difficulties at the moment because goals are being redefined (for example, by new environmental laws) and because procedures, requirements, and standards are being elaborated and to some extent confused, one can hope in the long run for reasonable solutions.

So this case history of the societal guidance of a major new technology is encouraging in its suggestion that, despite difficulties, processes to guide specific technologies toward preselected societal objectives can indeed be worked out. It is encouraging also because these processes were developed without the motivation of even minor disasters.

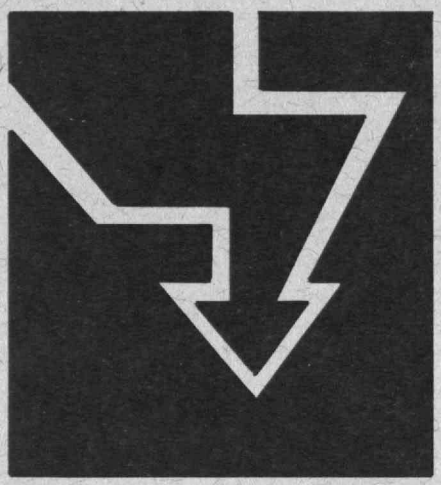
Whether such processes can or will be developed on a world-wide basis fast enough to beneficially guide the rapidly increasing use of all the new and powerful tools and techniques of mankind is an open question. But there is no chance of solving such problems if, because of discouragement, we make no attempt or if we expect simplistic solutions and overnight answers. Any successful process of defining societal goals and evolving methods for the control of man's tools will have to be based on gathering information and thinking about it. In a word, science—political, social, economic, psychological and physical science—is the only workable basis. Those who, like the prospective bomber I mentioned, reject such a process and propose destroying existing systems and institutions and starting all over, are on the wrong track—a potentially disastrous one.

Following the path of thoughtful action requires care. The logic must be broadly based, so that whole problems are compassed, not just parts of them, and so that methods adopted have no irreversible hidden traps. And the overall objectives must be based on some system of values. No one, even including the U.S. National Academies of Science and Engineering, has yet been right enough about values, goals and methods to really understand and direct the very rapid spread of technology in general. Collectively, we are not sure what we want.

Technologists must now become far more active than heretofore in the effort to define goals and develop methods for societal guidance of our tools and techniques. I believe this is true not only because the effort of thinking men is needed, but also because engineers are more likely than others to understand how the tools can be modified in detail to achieve specific purposes. They may thus help inject some realism into the development of a philosophical and practical basis for action. A continuing series of evolving solutions over many years is probably the only realistic thing to hope for. I think it therefore especially important to call the attention of students to these matters, because contributions from those who are students now will probably be needed throughout their lifetimes.

by Richard A. Rice
Professor of Transportation
Carnegie-Mellon University

System Energy and Future Transportation



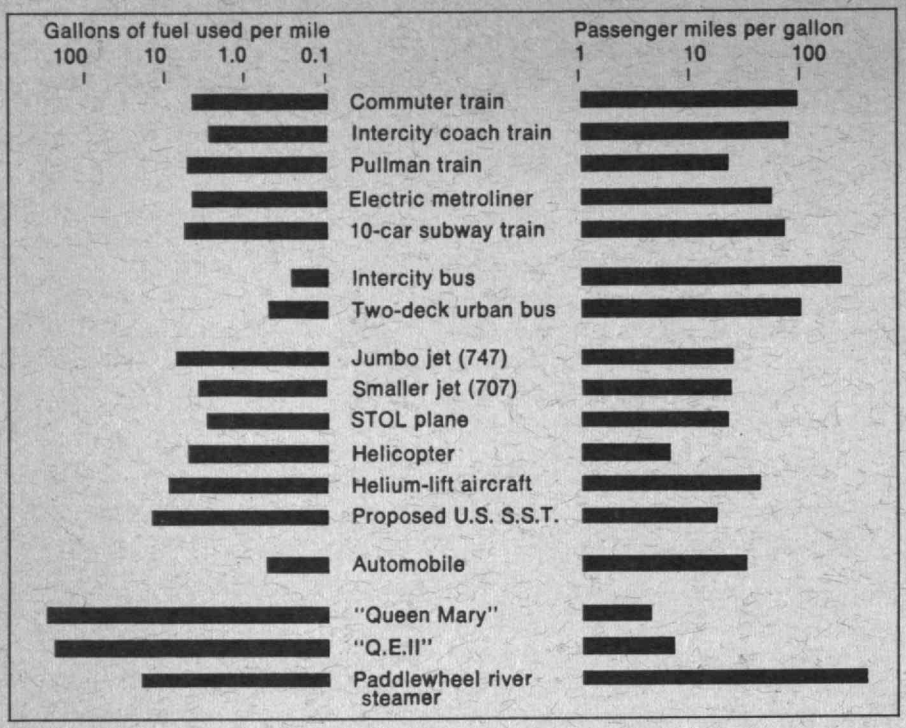
The United States in a typical year of the late 1960's used some 55,000 trillion B.t.u. of energy for all major activities. Transportation accounted for about 24 per cent of this total energy, or about 100 billion petroleum gallons if 130,000 B.t.u./gal. are allowed. This represents more than half of the 174 billion gal. of petroleum consumed in the U.S. It is a sufficiently large component of our total energy use to justify careful analysis, in a time when our overall energy supply-and-demand system is coming under ever-sharper scrutiny.

Transportation is responsible for about 20 per cent of the gross national product (G.N.P.)—in 1965, about $140 billion. It could be said that to "generate" $140 billion of transport user payments and charges, some 88 billion gal. of fuel (or the electrical equivalent) were used, and that each gallon burned thus "generated" some $1.60 of transport activity. With fuel and power generally available to the typical transport operator at 11 to 23 cents/gal., not including taxes, fuel—or energy cost—constituted between 10 and 15 per cent of all transport user costs for most transport modes.

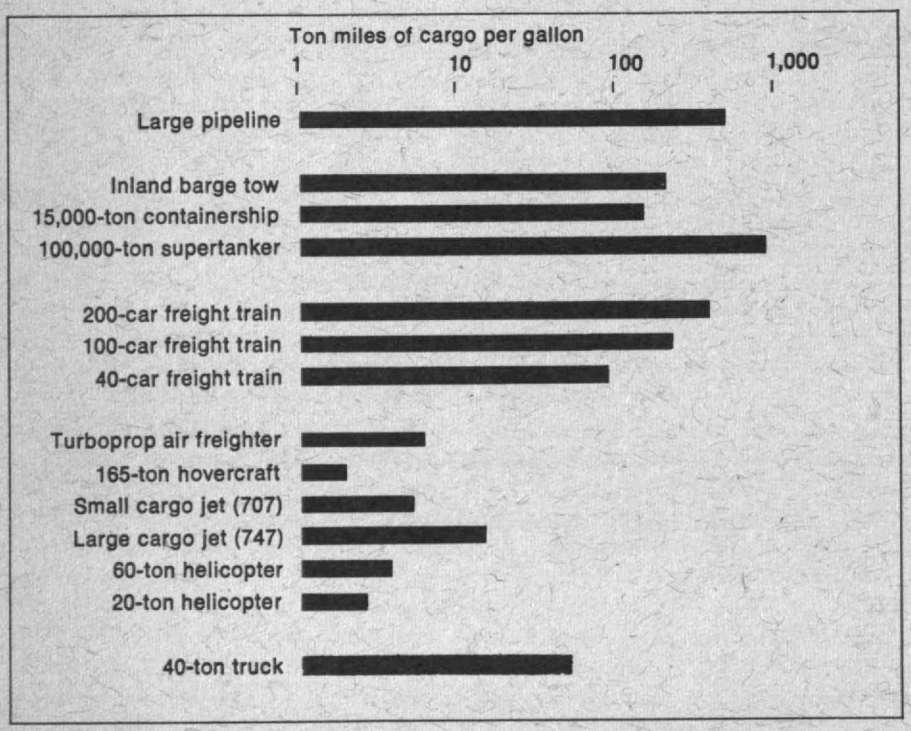
A second way of looking at this is that some 1,300 billion local and intercity passenger-miles and 2,000 billion local and intercity cargo-ton-miles were moved in 1965. The total movement of 3,300 billion capacity-miles by 88 billion gal. of fuel shows a total national propulsion efficiency of 37.5 net payload unit-miles/gal. used. Some 2,400 billion unit-miles of intercity transportation were accomplished with perhaps 41 billion gal. of fuel—a rate of 58 unit-miles/gal. The urban sector—with autos, transit, and regular trucks—may have generated 800 billion transportation miles with 40 billion gal. (20-miles/gal.). The balance, some 200 billion unit-miles not easily identified, must represent specialized services consuming the remaining 15 billion gal. of fuel at a yield of only 13 unit-miles/gal.

In the United States, in terms of gross-ton-miles moved (4,280 billion), the railways account for half the operation of nonurban transport. In the mid-1960's they moved over 2,200 billion gross-ton-miles annually with 4.0 billion gal. of diesel fuel; their gross efficiency, including passenger trains, was 550 ton-miles/gal. In contrast, the airlines used 2.0 billion gal. of fuel to fly only 60 billion gross-ton-miles. Highway vehicles moved 1,320 billion gross-ton-miles using 35.2 billion gal. for a general efficiency of 37.6 ton-miles/gal. Intercity transportation as a whole accounted for 41 billion gal. of petroleum—two-thirds used in private automobiles—and had a gross propulsion efficiency during the 1960's of 104 ton-miles/gal. The total *net* intercity propulsion efficiency was 58 unit-miles/gal. For freight, the figures (gross and net) were 290/140; for passengers, 33/26.

The figures for urban transportation are, of course, very different. Using 1965 estimates, all suburban railway transportation—6 billion passenger miles—required some 70 million gal. of petroleum or the equivalent in electric energy; this represents some 85 passenger-miles/gal. Other urban public passenger carriers—buses, limousines, taxicabs, etc.,—used 400 million gal. of fuel. Private automobiles in urban service used 35 billion gallons of fuel, 60 per cent in trips of 2½ miles or less. Add to these the totals for urban trucking and parcel delivery (5.4 billion gallons) and institutional vehicles (1.8 billion gal.), and the re-



In passenger transit, the high performers in terms of net passenger miles moved per gallon of fuel are buses and commuter trains; the more exotic, faster means of transport are lower in efficiency, and so are such hard-to-die luxuries as superliners and Pullman (overnight) trains. A trend to the most efficient forms of passenger transport, writes the author, would considerably increase the U.S. national propulsion efficiency. Note that the horizontal scales are logarithmic.



In freight service pipelines, inland waterways, and railroads do not use significant amounts of energy in relation to goods moved. In fact, writes the author, in 1965 these three forms of transport used only about 5.5 billion gal. of petroleum (7 per cent of U.S. transport energy) to provide 1,250 billion cargo-ton-miles of service and 60 per cent of all gross ton-miles moved in the U.S. Note that the horizontal scale is logarithmic.

sult is 42.7 billion gal. of petroleum or equivalent annually devoted to U.S. urban transportation in the mid 1960's.

In addition to the above, a small part of the fuel recorded as used in intercity traffic is in fact used within urban areas at the start and end of each intercity trip. Thus one may hypothesize that perhaps as much as 47 billion gal. of petroleum or equivalent energy was consumed for transportation within the 2 per cent of the U.S. continental area classified as urban; 41 billion gal. were burned in the other 98 per cent of the country.

Future Petroleum Commitments

Since the typical single automobile runs 10,000 miles per year and in so doing uses 670 gal. of fuel, it is easy to see that it is consuming about two tons of petroleum annually. In other words, the auto just about consumes its own weight in fuel every 12 months. In 1960 there were in the world a total of about 150 million autos, using 300 million tons of petroleum.

It is revealing to compare this with the annual energy consumption of a few other transport craft units, as shown in the table on page 33. A bus consumes six times its weight. A DC-6 uses 70 times, and a 707, 175 times its weight. The proposed 375-ton S.S.T. would have swallowed 240,000 tons of fuel, or 640 times its takeoff weight, per year. The old "Queen Mary" superliner of 160,000 h.p. used almost 400 gal./mi. of "Bunker 'C'" fuel oil to drive her across the Atlantic: in a year, she used up to 200,000 tons of petroleum —compared to her gross weight of 80,000 tons. But a single Concorde S.S.T. aircraft, weighing 180 tons and flying 11 hrs./day, might consume 25 million gal. of fuel annually; and the present jumbo-jet—at 320 tons—21.5 million gal. A fleet of 900 of the latter—which has been forecast—makes our future petroleum commitment look alarmingly sizable.

Indeed, if all present air carrier transport plans should materialize, some 88 billion additional gallons of fuel might be required per year for transportation by 1985. Of this increase, automobiles are estimated to need 28 billion gal. and larger air transport craft, 43.5 billion gal. Together, they account for 80 per cent of the projected increase.

Another large increase, 4 billion

gal., would be required by intercity trucking, while smaller private planes would need 4.7 billion gal. more. Railroads, buses, pipelines, and waterways combined would require 3.7 billion gal. more. The latter four carriers are thus not critical contributors to the projected soaring petroleum demand, and some extension of railroad piggyback service could, in addition, alleviate the 4-billion-gal. increase that trucks otherwise might need. This leaves automobiles and aircraft as the targets for further study if we are compelled to revise future fuel commitments.

Urban Transport Energy Needs

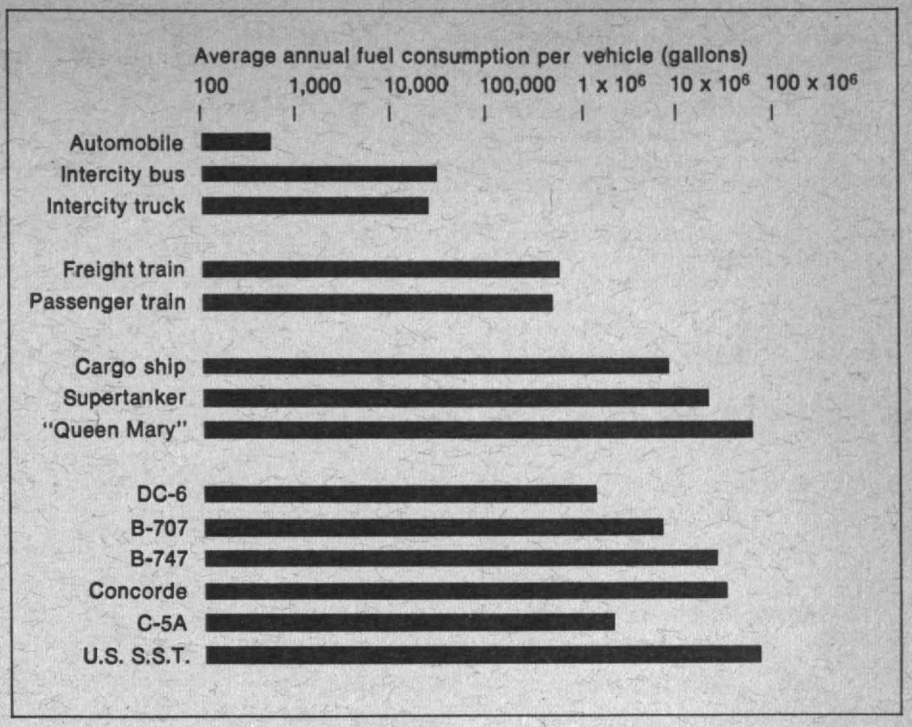
In anticipating fuel requirements and in planning the directions for future technological development, it is instructive to compare the true energy efficiencies of various transport modes. This is done in the accompanying tables on the basis of their net propulsion efficiencies (N.P.E.'s), the number of cargo-ton-miles or passenger-miles moved per gallon of fuel.

In passenger transport, the high performers seem to be buses and commuter trains with N.P.E.'s of 100 or over. These provide the highest yield, and a trend to these modes would increase our national propulsion efficiency.

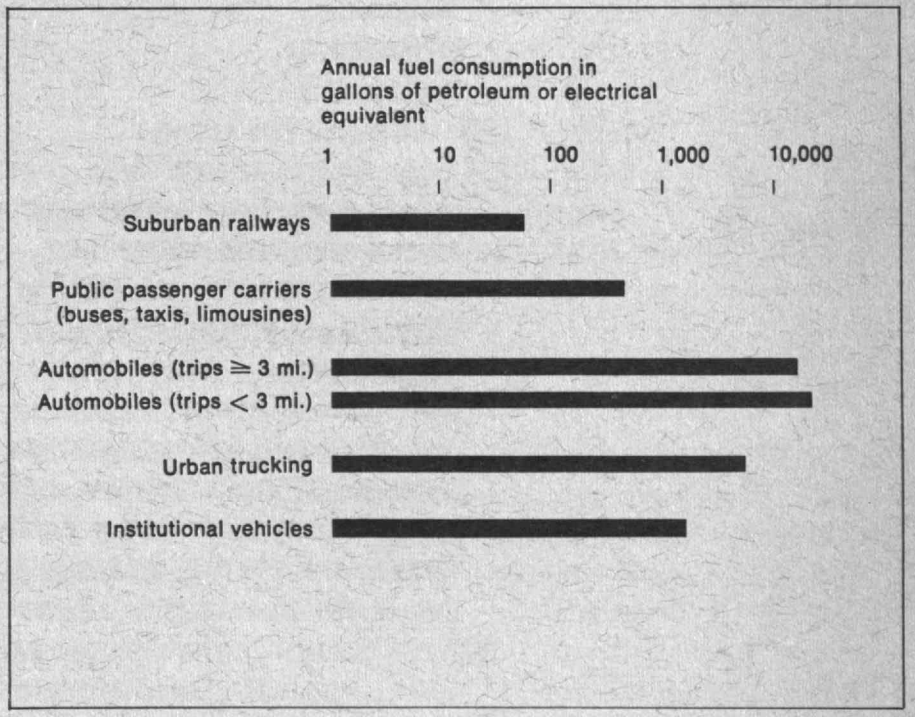
The automobile with an N.P.E. around 30 to 40 is about average for passenger movement. Air transportation is slightly less efficient. Such now-largely-discontinued methods as the ocean liner and the Pullman sleeper may owe their decline in part to their low N.P.E. deriving from their high weights per passenger. However, three proposed modes for future overland service—the S.S.T., the helicopter, and the hovertrain—all seem to have lower N.P.E.'s than even conventional autos or air travel.

In 1960, domestic trunk air-route service required approximately 2 billion gal. of fuel (in 1955, it was only about one billion). By 1965, domestic routes required about 4 billion gal. and in 1970, 8 billion. Between 1955 and 1970, the regular domestic-route airlines thus increased their fuel consumption about eight times, while the traffic carried in terms of passenger-miles rose only about six times.

Pipelines, inland waterways, and railroad freight do not use significant

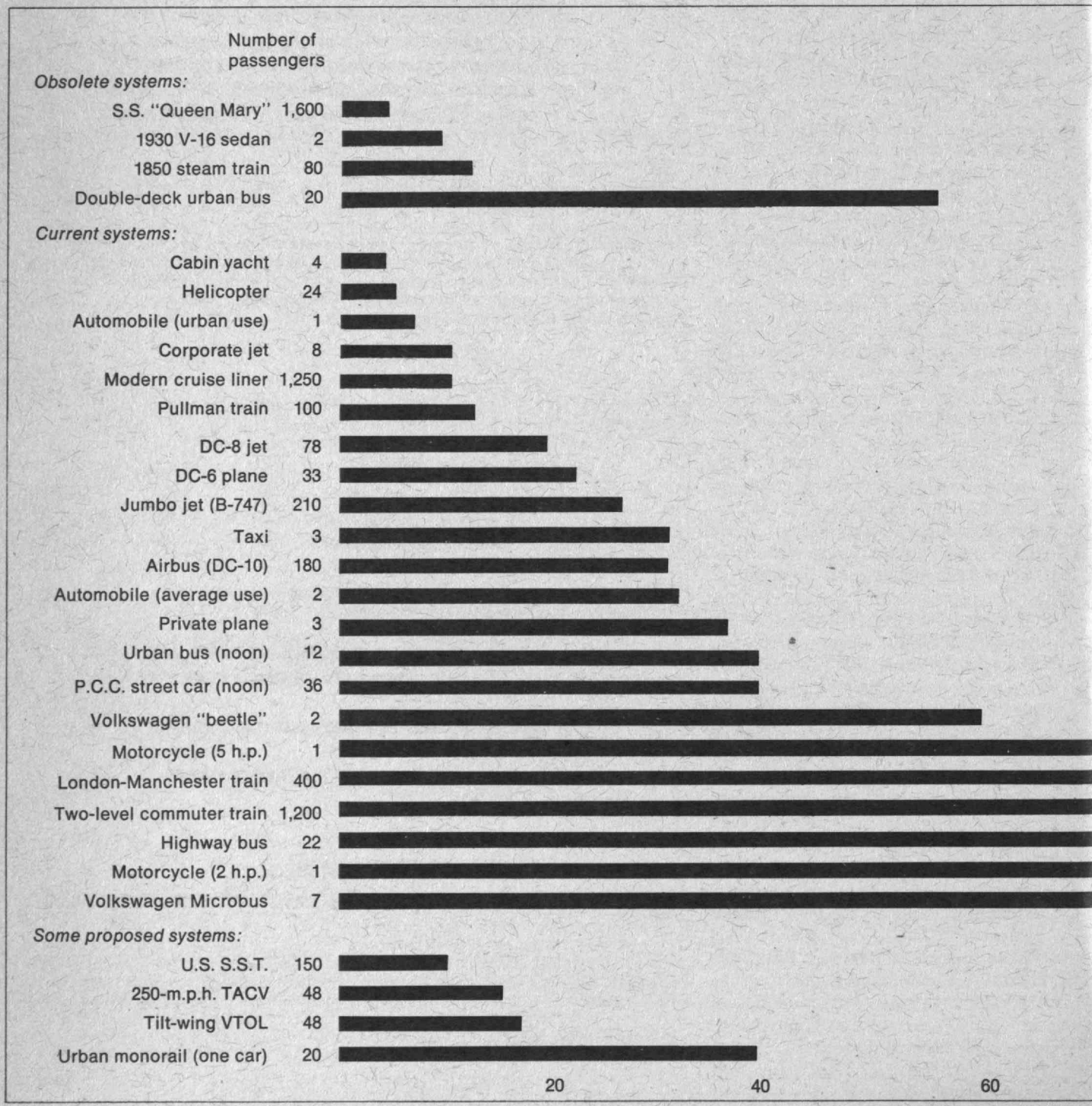


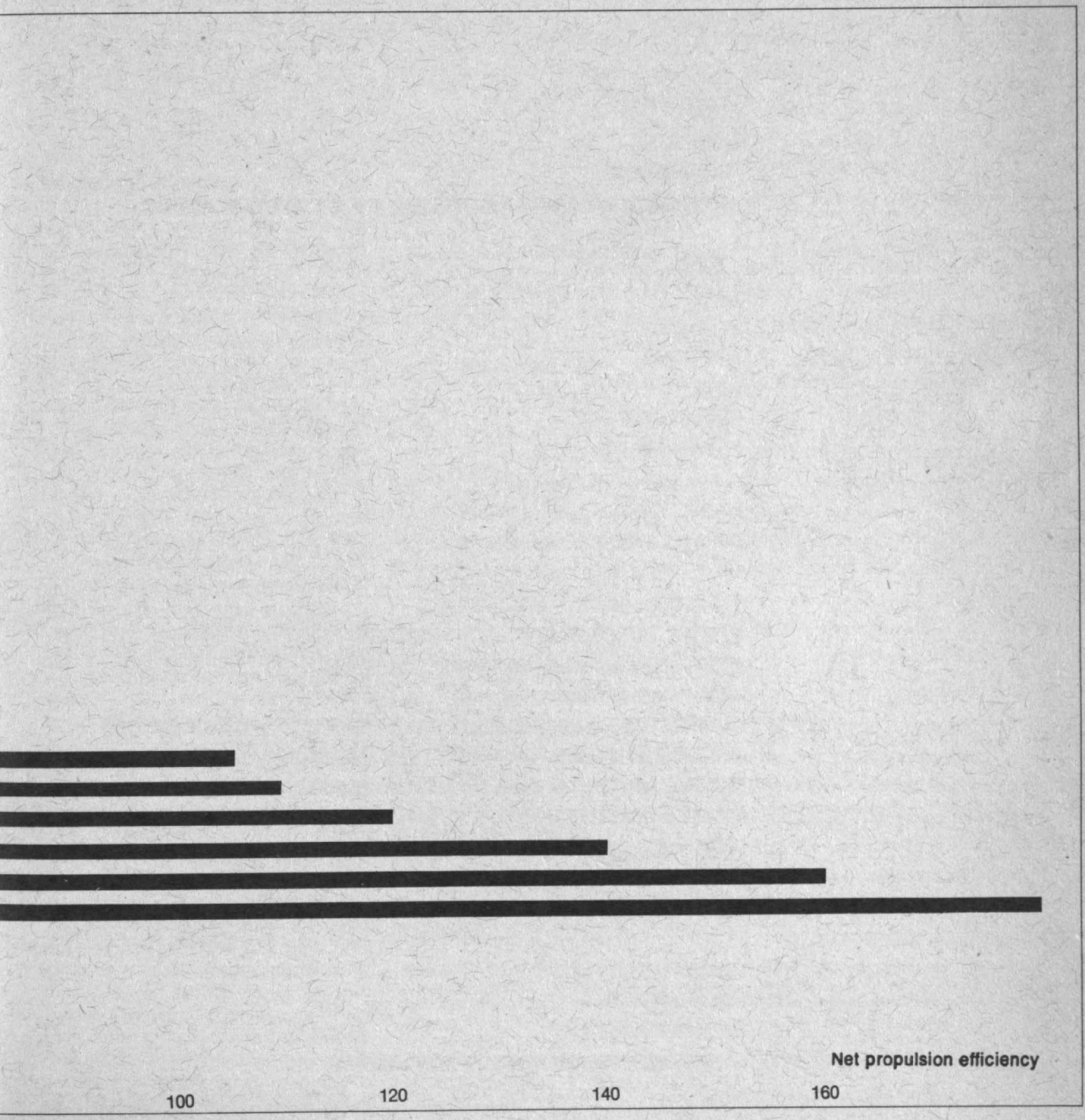
If and when absolute fuel consumption becomes a primary issue in transportation planning, engineers will discover how extravagant are today's more exotic (and faster) forms of transit. The figures given above are based on the current average service required of each vehicle, ranging from less than one hour per day for the automobile to 20 hours per day for a supertanker. Though freight cars move an average of only about one hour a day, locomotives (the figure above) are estimated at between 5 and 6 hours' travel per day. Note that the horizontal scale is logarithmic.

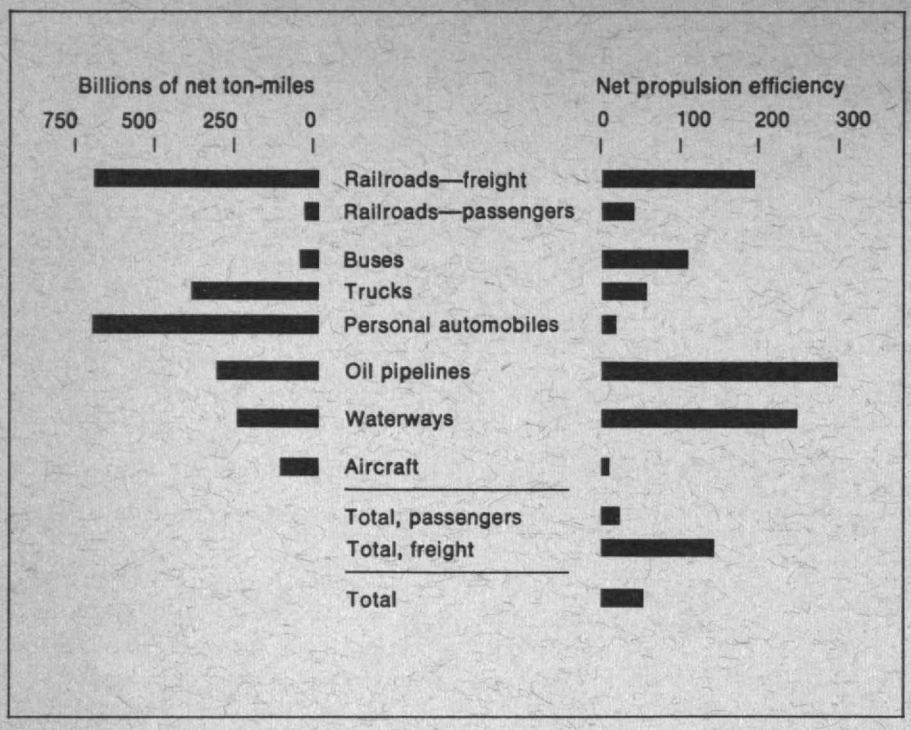


Automobiles have by far the greatest claim on energy resources used for urban transportation. A major reduction in energy expended—and presumably in urban pollution problems—could be achieved if automobiles could be eliminated for trips of three miles and less. While an automobile accomplishes some 30 to 40 passenger-miles of transport per gallon of fuel used, a bicyclist obtains about 1,000 passenger-miles for the same energy input, about 130,000 B.t.u. or 34,000 calories (kcal.)

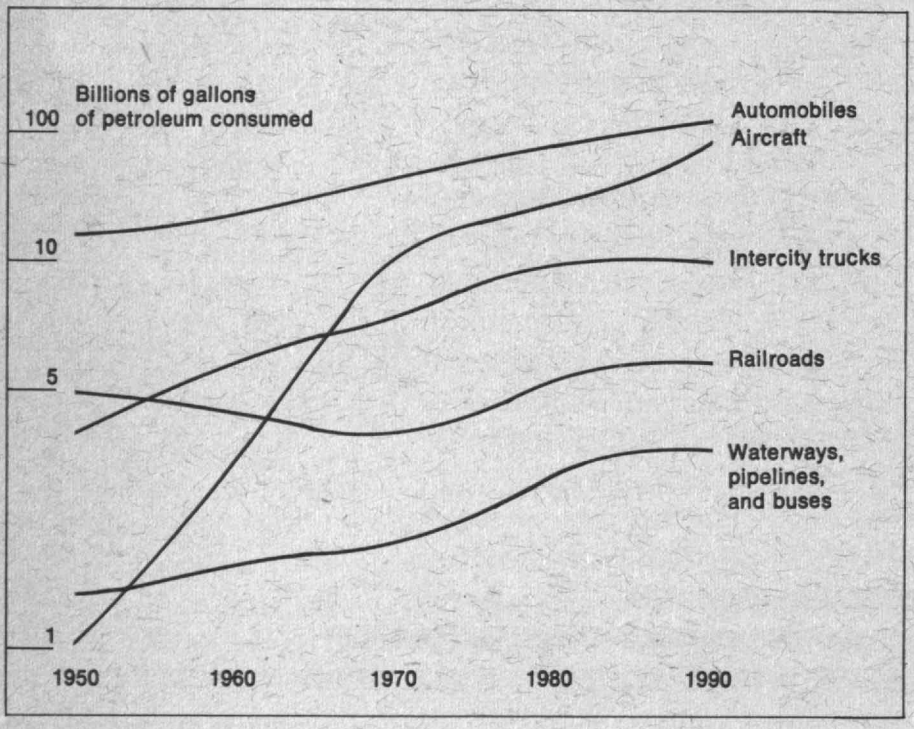
All of the principal system alternatives for passenger transportation for which data are readily available are compared in this chart in terms of their net propulsion efficiency, the number of passenger-miles moved per gallon of fuel. Note that the number of passengers on which the efficiency is calculated is not necessarily a maximum capacity but is instead an average figure for present experience. Efficiency rises dramatically as more passengers are accommodated; with three occupants a Volkswagen "beetle" comes out with a net propulsion efficiency of 100.




Net propulsion efficiency
100
120
140
160



Intercity transport of passengers and freight in the U.S. varies markedly in efficiency, as measured in terms of the net payload (pounds or individuals) carried per gallon of fuel consumed. If our goal is to increase a total national propulsion efficiency, we will concentrate on those methods of moving goods and people which show the highest net propulsion efficiency.



Current government policy favors the development of air and highway transport. If planning subsidies continue to encourage use of these methods, automobiles, aircraft, and trucks will maintain their growth as transportation methods. But the propulsion efficiency data presented by the author suggest that changes in national policies and priorities may in fact be overdue, and he suggests that the balance between transportation methods may be altered before 1990.

amounts of energy in relation to goods moved. In fact, at about 1965 levels, these three carriers used only 5.5 billion gal. of petroleum (or about 7 per cent of U.S. transport energy) but provided some 1,250 billion cargo-ton-miles or roughly 40 per cent of all useful overland passenger and ton-miles generated. In terms of gross ton-miles moved, these three carriers accounted for 60 per cent of all transport.

Trucks achieve approximately 50 cargo-ton-miles/gal., less than half the efficiency of intercity freight as a whole. Airfreight transport, which apparently yields only about five to ten cargo-ton-miles/gal., thus appears suitable only for goods requiring more expedited service.

Projected Total Energy and Transport Outlook

Long-range forecasts indicate that total U.S. energy use may continue at about 100,000 B.t.u. per dollar of gross national product (true G.N.P. in terms of 1958 dollars). Taking median government forecasts of G.N.P. of $970 billion in 1980 and $1,300 billion in 1990, the corresponding energy forecasts for trillions of B.t.u. are 108,000 and 145,000 respectively.

Inserting the most optimistic air transport fleet data and high auto-use projections, we find that in 1980, aircraft and autos might consume 77 per cent of transport energy and in 1990 an estimated 82 per cent. In 1960 and 1970, these figures were 60 and 68 per cent, respectively.

Of the projected growth of 163 billion gal. of petroleum consumption from 1960 to 1990, air and autos would thus consume 150 billion gal. or 92 per cent. This increase by 1990 in air and auto usage alone is far more than the entire 1960 transport energy use.

The impact of such an increase attributed to the two relatively high-energy transport modes is hard to anticipate. But it is probably fair to suggest that unless air travel can deliver more than the current 20 to 25 passenger-miles/gal., the increase projected will in fact not be fulfilled. The prospect for burning from 50 to 90 times as much petroleum in the sky as in 1950 does not look realistic in view of current concern over air pollution; and the same concerns may also serve to stimulate alternatives to the motor vehicle for intercity and urban transport. Fur-

The human being and the bicycle are uniquely efficient as transport, and man's increasingly innovative devices are uniquely inefficient. As energy becomes more costly, propulsion efficiency may become a criterion of wide concern.

thermore, if fuel supplies grow short, efficiency will become an issue of greater concern; and public attention is likely to focus on the vastly more efficient rail, water, pipeline, and even large truck systems.

Human Energy as a Transport Standard

While the chemistry and metabolic rates associated with human activities—especially walking, cycling, canoeing, and hiking—have long fascinated scientists, it is only recently that consideration has been given to the environmental desirability of encouraging human propulsion as a substitute for the urban auto. Human propulsion energy needs are quite small.

The Sierra Club advises that hikers planning their daily trek should allow one hour for each 2½ miles along level trails, plus one hour for each 1,000 ft. of vertical ascent. Assuming a 160-lb. man, the continuous "hiking thrust" at a 2.5-m.p.h. walk works out to 12.3 lb. or 0.082 h.p. for a smooth trail. Ascending at the rate of 1,000 ft./hr. (160,000 ft.-lb./hr.), we get 2,670 ft.-lb./min. or also 0.082 h.p. These rough estimates would indicate that a slow walk requires around 1/12 h.p.

The author's studies of bicycling indicate that, assuming 40 lb. for the vehicle, a thrust of 6.7 lb. is required to average 15 m.p.h. on the level, or about 0.27 h.p. At 20-m.p.h., a 10-lb. thrust indicates power up to 0.5 h.p. Leisurely cycling at 10 to 12 m.p.h. with five-lb. thrust thus is estimated to use about 1/8 to 1/6 h.p.

Many sources confirm that a person hiking or cycling five to six hours daily will actually add some 1,500 to 1,800 calories to his average daily need. Thus a very rough estimate of human propulsion efficiency can be made by noting that 1,800 "extra" calories of input in a moderately active male can yield at least ⅛ h.p. for five to six hours of measurable output—a total of 0.75 horsepower-hours.

For the 1,800 calories (7,000 B.t.u.) that a cyclist uses, he is travelling some 72 miles at 12 m.p.h.: figuring a 200-pound craft (cyclist and cycle), he is performing 7.2 gross-ton-miles of transport work. This implies a propulsive efficiency of over 45 per cent for a male cyclist in good condition, while most engine-powered units have a net propulsive yield of about 25 per cent. In terms of petroleum units, a cyclist can reach the equivalent of over 1,000 passenger-miles per gallon, per 130,000 B.t.u., or per 34,000 calories.

If bicycle and pedestrian journeys were substituted for two-thirds of the 2,050 trips of two miles or less that most urban autos make per year, the savings per household (@1.3 autos) would be 1,800 trips involving 270 gal. of fuel (about 35 million B.t.u. per household). For this there would presumably be substituted the requisite 1,800 personal one-way trips, each of which by cycle or walking would consume only about 500 B.t.u. of human energy from 130 calories. The annual household total for these 1,800 trips is thus about 1 million human B.t.u., which replaces the 35 million automobile B.t.u. Extrapolation of this 35-fold saving to a city of 1 million population owning 300,000 autos and using 80 million gal. of fuel (around 10×10^{12} B.t.u.) yields a significantly lower fuel consumption.

Long-Run Energy Implications

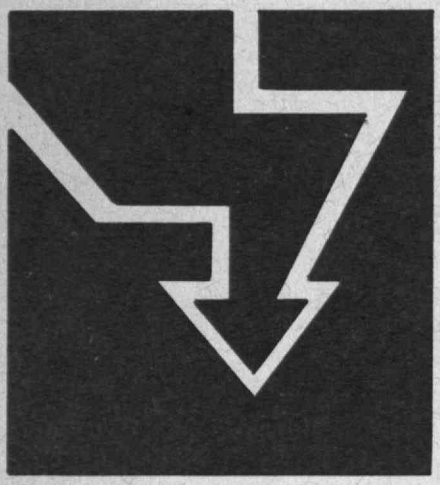
Though projections for increased U.S. energy use, and especially petroleum use, can be made based upon G.N.P., the limitations on both petroleum supplies and energy-caused atmospheric pollution make the forecasts for both total and transport use appear questionable. The consumption of fuel per delivered passenger or per delivered ton will assume increasing importance, and here the high-yield systems continue to be the waterways, the pipelines, the railroads, and passenger buses. All of these have propulsion efficiencies in the 100 to 300 range.

Heavy reliance on highly innovative systems in the near future seems doubtful because of the low yields proposed for most of them—hovercraft and helicopters, for example. Even the automobile (30 to 40 passenger-miles/gal.) and the intercity truck (50 to 60 ton-miles/gal.) may have to be curtailed or drastically changed to improve the overall national propulsion efficiency. Continued quantum enlargement of air travel systems yielding only 20 to 30 passenger-miles/gal. (let alone the S.S.T. at 10 to 15) will so increase total petroleum use and so reduce the N.P.E. as to certainly cause early review. The very optimistic jet, jumbo-jet, and S.S.T. fleet projections of just a few years ago carry with them implications for total fuel consumption which begin to appear unrealistic.

These calculations of energy-efficiency suggest modest redirections for intercity transport development, but urban transportation methods appear to be candidates for more drastic changes. Perhaps as much as a 50 to 70 per cent reduction in urban motoring—and a substitution in even amounts of walking, cycling, and mass transit—will be needed to produce a noticeable effect on urban transport energy consumption.

by Hoyt C. Hottel
and Jack B. Howard
Department of Chemical Engineering and the Environmental Laboratory, M.I.T.

An Agenda for Energy



Although the magnitude of today's energy problems has frequently been stressed, the term "energy problems" has different connotations to different people. Some think primarily of blackouts and the need for guaranteed continuity of electric power, without visualizing how difficult and, increasingly, how unacceptable is a continued growth that follows the patterns of the past in meeting growing demands. Others think primarily of environmental problems and are impatient with the slow change in the growth patterns. In this article the term "energy problems" relates to the technological status of our energy and fuel conversion processes, present and projected. Our objective is to assess the technical and economic adequacy of existing or proposed processes and their consistency with developing standards of environmental quality, and to suggest where additional effort—research, development, demonstration plants—is most needed to accelerate change.

There are problems in reporting any technological assessment to an audience whose interests are varied and to a considerable extent unknown. To a planner—say, a statesman or an economist—the conclusions from a technological assessment suffice as inputs to his thinking; given the statement that a certain process works, should cost about so much to develop and so much to operate, and does not violate environmental constraints, proper action can be taken. To an engineer or scientist, on the other hand, any process that is not in industrial use is almost by definition replete with unsolved problems, and any stated conclusion as to how much research or development is necessary to make the process viable is subject to reevaluation; an exposition of process details is an essential background for acceptance of any stated conclusions. This report is written for a general audience presumed to include both, and readers should be aware of the biases with which they approach what follows.

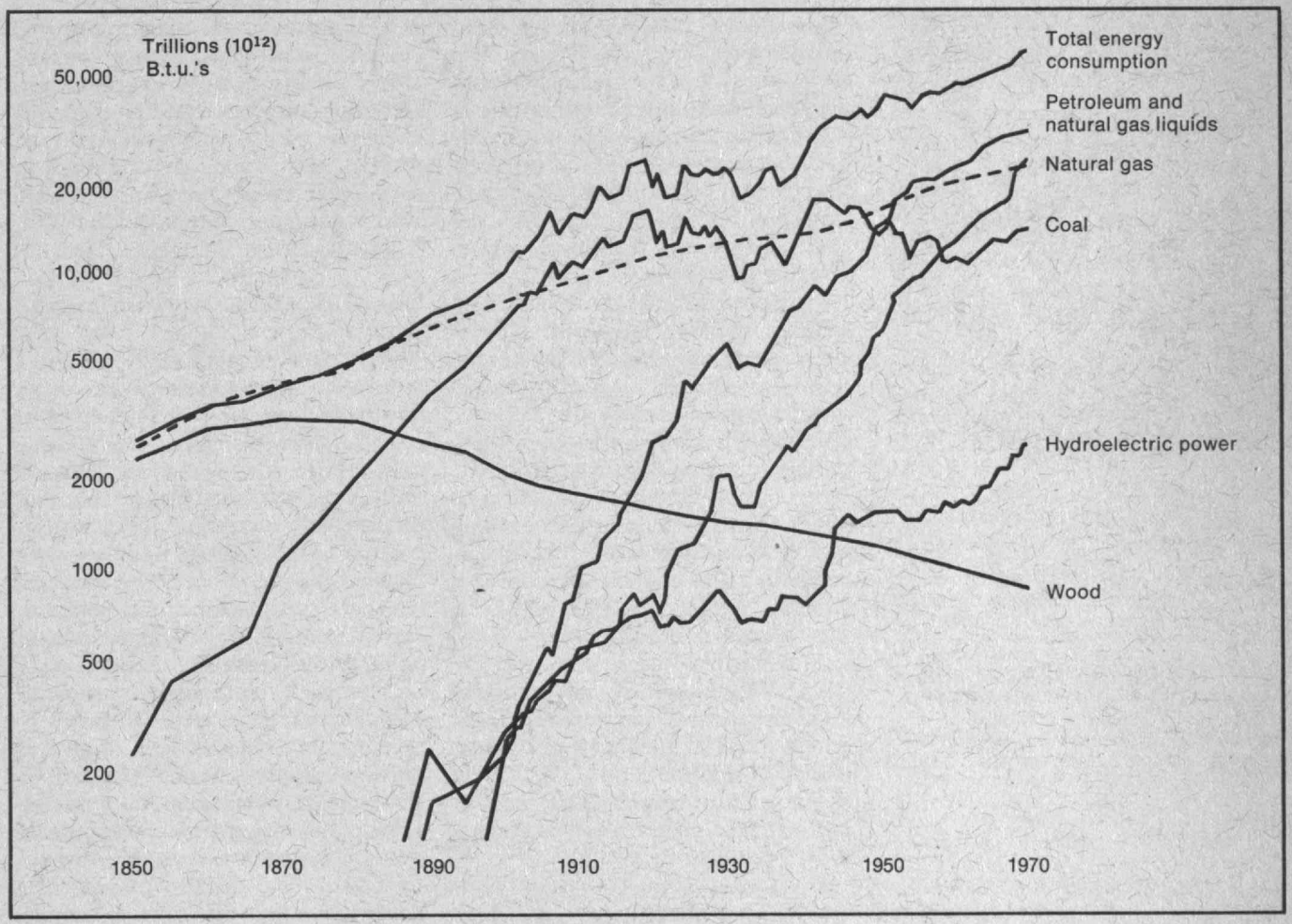
Energy Supply and Demand, Past and Present

The pattern of United States consumption of energy—wood, coal, crude oil, natural gas, hydroenergy, and nuclear—shown on the accompanying chart, will be familiar to most readers. The history of our energy supply and demand is not without drama, and readers with long memories will identify some of its irregularities with vivid personal experience. Among the many points meriting discussion are these:

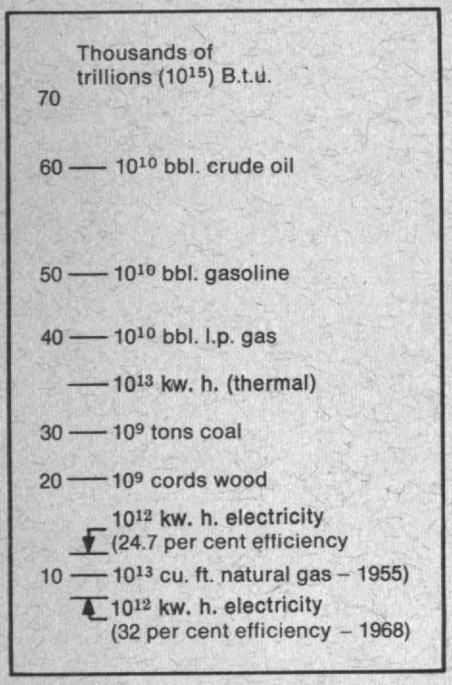
☐ We enjoy, individually, such a short span of responsible involvement in energy problems that we tend to lose track of how similar, in some respects, the past patterns of energy growth or replacement have been to those of our day. We tend to think, because today's numbers are large, that all changes of real significance have happened recently; and "recently" means "since I was about 25." The logarithmic scale of the chart (p. 39) tends to cure this defect. The most striking feature of the plot is the relentless and almost constant upward march of energy consumption, which causes the industrialist or engineer of 1971 to echo the words of his great grandfather, "Never in history has energy consumption matched ours."

☐ The past pattern of growth would not look so much like the present one as it really does if wood, left out of most modern compilations

Improved energy conversion and utilization need not await such exotic technology as breeder reactors, magnetohydrodynamics, and nuclear fusion. More conventional engineering development holds significant promise for the near term.



The history of U.S. energy sources and consumption since 1850 is replete with drama—which is often concealed by rounding curves to concentrate on the familiar, inexorable rise in energy demand. Look, for example, for the drop in energy consumption corresponding to economic depressions in the early 1920's and most noticeably in the early 1930's; the increasing consumption of coal in war-time, both in 1918 and 1941-46; and the gradual advance, since late in the 19th century, of energy consumption in relation to population. The logarithmic vertical scale helps to suggest how similar to those of recent decades have been past patterns of energy growth and replacement. The dotted line shows population growth, plotted on a scale of the ordinate numbers times 10^4.



This conversion chart compares, on a scale readily comparable with the previous figure, the energy represented in various resources commonly used in the U.S.

of energy, had been left out here. Only when it is included is the line of growth nearly straight back to 1850. Its inclusion in the present-day summation, however, adds only 1 per cent.

☐ New fuels have always come in with a steep slope, not generally displacing but adding to the contribution of established fuels. Integration of a new fuel into the economy has occurred in reasonably similar patterns three times. This can be demonstrated on the chart on page 39: by laying off distances along the edge of a piece of paper corresponding to factors of 10 and 5 on the chart and sliding the paper along under the top line to establish intersections with the various fuels, one finds the years at which a fuel contributed first 10 per cent and then 20 per cent of the total. This happened for coal in 1851 and 16 years later, and for oil in 1918 and nine years later, for gas in 1935 and 17 years later. The average annual growth rate of gas of 6 per cent per year for 15 years from 1955 to 1970 is considered phenomenal; but it was more than matched by petroleum during the 22-year period from 1934 to 1956.

☐ Coal has had a curious growth pattern. Consumption was 13.6×10^{15} B.t.u. both in 1912 and in 1970; it has oscillated around that number, hitting highs of 17×10^{15} B.t.u. in the war years 1918 and 1943 and lows of 9 to 10×10^{15} B.t.u. in 1932 and 1958. The trend has been upward for the last nine years.

☐ Nuclear power is just coming into the picture; energy from wood is estimated to be today four times that from nuclear sources. The latter is, of course, growing fast, and its position is somewhat comparable to that of petroleum in 1900.

The total U.S. energy consumption has been growing somewhat faster than the population, at least since 1885. U.S. consumption per capita in 1970 was 338×10^{6} B.t.u./yr., equivalent to about 6.7 gallons of petroleum per day or 80 times the human caloric intake. This can be visualized as the equivalent of 80 slaves working for each one of us to maintain our modern, affluent way of life. It is perhaps surprising to realize that the last 50 years have seen less than a 70 per cent increase in per capita energy consumption.

Increasing energy consumption should produce an increase in goods, measured by per capita gross national product (G.N.P.), and services. If goods and services are produced in constant ratio, the G.N.P. per unit of energy consumed should measure efficiency of energy use. With some faltering, this ratio of G.N.P. to energy consumption has marched upward from 1920 to 1955, indicating a continuing increase in the effectiveness of using energy. From 1955 the growth was slow, and since 1967 it has turned down. This could mean that there has been a loss in efficiency of energy use; more probably it means that the ratio of services to goods is increasing. Combined with the continuing increase in per capita energy consumption, it is a possible warning sign.

The first chart showed where our energy has been coming from; the one on p. 42—a double bar graph, divided vertically according to category of use and horizontally according to fuel type, shows how it is being used. As a general guide to placing problems in perspective, a handy approximation of its data is as follows: about one-third of our energy is consumed in the industrial category, one-fourth each in transportation and utilities, including electricity, and one-fifth in household and commercial use. The picture will of course change, particularly the fractional consumption in producing electric power; electrical energy production is expected to double in 10 years.

The picture of United States energy consumption is not complete without identifying its relation to the world total, and the striking feature of any such analysis is how much additional energy—a six-fold increase—would be involved if the rest of the world's appetite and capacity to produce approached ours. World consumption is in fact grow-

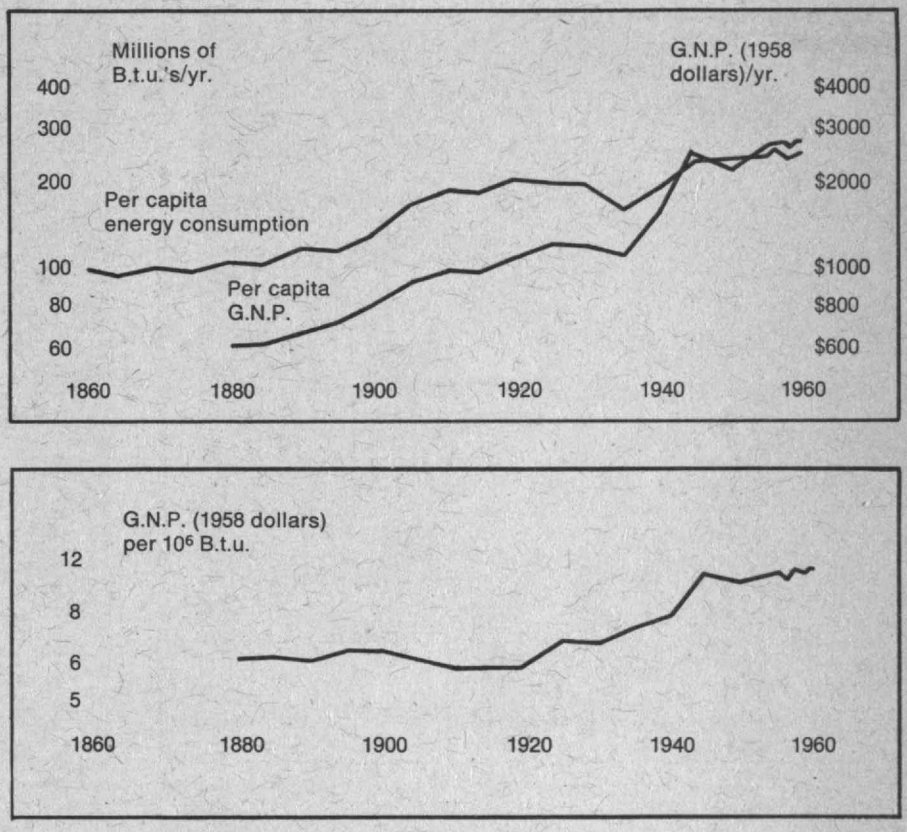
Regardless of which projection is accepted, and accepting the fact that curves that maintain a constant percentage growth per year cannot continue forever in a finite world, the inescapable conclusion is that energy demands by the end of this century will be enormous...

ing faster than that of the United States, with West Germany, Japan, and France leading the increase. The fraction of the world's energy consumed by the United States is expected to drop from 34.8 per cent in 1967 to 26.8 per cent in 1980.

Projection of Energy Demand and Sources

If the previous discussion suggested that growth patterns of the future can be expected to follow those of the past, that was not the intention. Curves that maintain a constant percentage growth per year cannot continue forever in a finite world. This limitation has been clearly understood by projectors of the past 40 years; in consequence, however, they have generally underpredicted future energy requirements. There is increasing belief that the growth rate of total energy consumption must in fact change "soon" because of material and thermal pollution, but "soon" means 1985 to some, 2000 to others, still later to others.

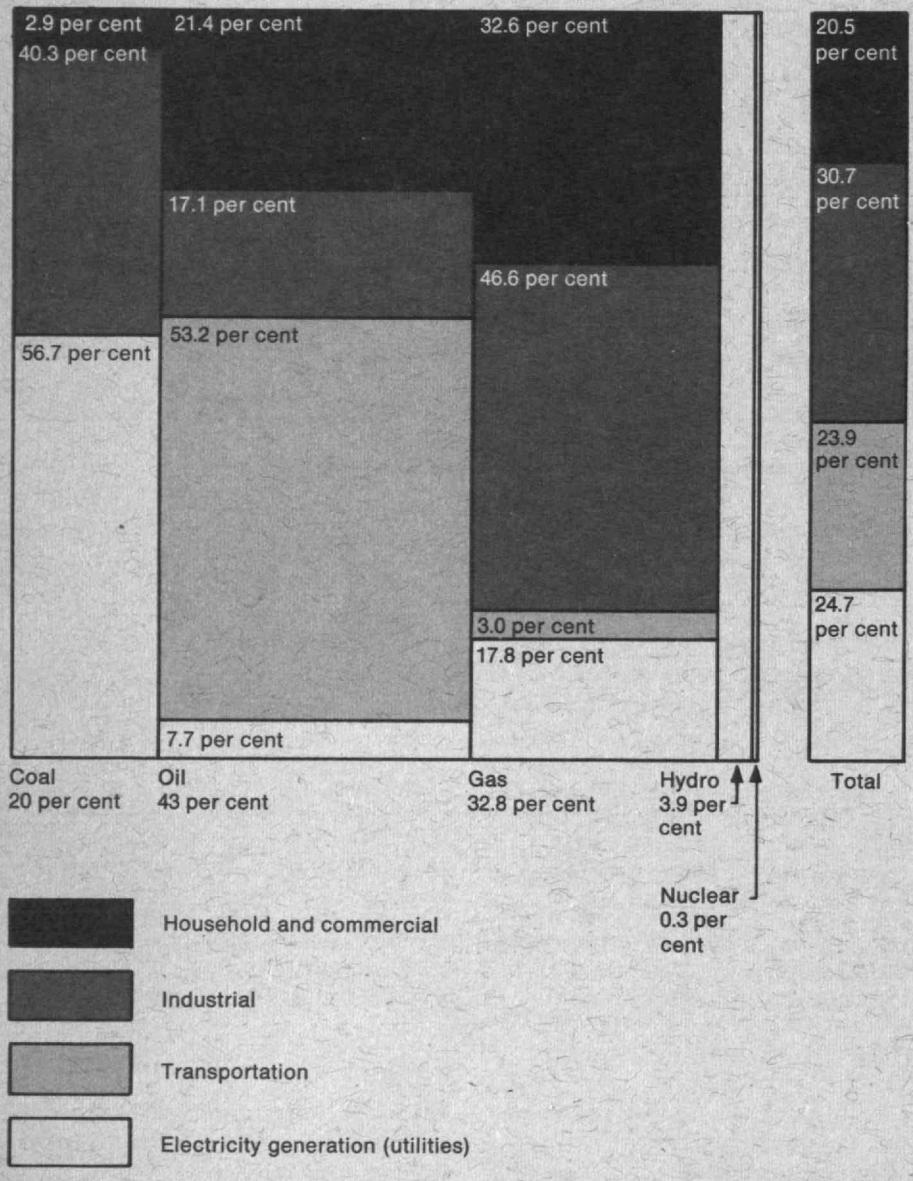
Summarizing some of the many recent studies of how to project the energy-demand curve, Battelle Memorial Institute in 1969 concluded that the most probable growth rate from 1970 to 2000 is 3.2 per cent per year (doubling every 22 years). This is the exact average that prevailed from 1931 or 1937 to 1970, if the last nine years 1961 to 1970—when the average annual growth rate has been 4.5 per cent (15.5-year doubling)—is taken to represent only part of the curve. Speaking at an M.I.T. Alumni Seminar in April, 1971, Frank A. Ritchings, Vice President of Ebasco Services, Inc., anticipated a growth rate of 4.35 per cent from 1970 to 1980 and 3.5 per cent from 1980 to 1990. These two projections probably represent the limits of present predictive judgment.



Per capita energy consumption in the U.S. stayed constant for the first 35 years of the record beginning in 1850, then began the relatively steady rise which led to doubling between 1885 and 1920, fell precipitously during the great depression, and has had a generally upward trend since 1932. The ratio of G.N.P. to energy consumption is shown by the single lower curve, which is in fact a measure of our generally increasing efficiency of energy use in terms of G.N.P. achieved for a given expenditure of energy.

Regardless of which of these projections is accepted, the conclusion is the now-generally-accepted one—that energy demands by the end of this century will be enormous by present standards. If to this U.S. growth is added the expected more rapid growth in the rest of the world, it is clear that our capacity to handle the situation will require the effective contribution of the scientist, the engineer, the economist, the industrialist, and the statesman.

Space and time prevent an adequate consideration of resources available to meet these energy needs. Suffice it to say here that coal, shale oil, and tar sands are available to supply our needs for centuries if natural gas and oil run out; enough uranium is available to satisfy our electrical needs for far longer when



This double bar graph, divided vertically according to category of energy use and horizontally according to fuel source, shows quantitatively the relative contribution of a particular fuel to a particular end use, by the area of the labeled item. For example, coal contributes 21.4 per cent to the total energy input (bottom of left column), and coal use by public utilities to generate electricity is 53.5 per cent of 0.214, or 11.4 per cent of total U.S. energy use. The sum of the separate fuel contributions to each of four categories of use appears in the small bar graph at the right.

breeder technology is developed; and, if our conscience should bother us concerning our descendants in the year 3000, enough solar energy reaches the earth to supply our needs if we do not overpopulate the planet. But prodigal use of any of our resources will be accompanied by an increasing fractional expenditure of our total productive effort on winning the energy needed for complementing that 1/25 horsepower device, the human body. The balance of this article is devoted to a discussion of our present efficiency of energy conversion and utilization and of some technological issues which must be resolved to maintain or increase that efficiency.

Assessing New Energy Technology

Common to the assessment of various fuel conversion processes is a body of technical information on energy transportation, energy storage, and pollution. This material, summarized in the following paragraphs, is largely factual; few comments on needs or implications of research or development are pertinent.

Only a few examples need be cited to suggest the relevance of comparative cost figures on energy transportation. Shall we move fossil fuel to power-demand centers or transmit electric power from a generating plant at the fuel source? Shall we avoid the high cost of solving the thermal pollution problems of a particular nuclear plant location by transmitting power from a thermally more favorable locale? Shall we move coal to a gas plant near a center of gas demand or pipe the gas over long distances from a cheap-coal area? Shall we burn liquefied natural gas from Libya or locally-made synthetic gas?

The cost of transporting energy is an essential element of the formula by which we may determine present and future strategy. But it is surprisingly difficult to discover truly comparable figures.

Briefly summarized on a common basis of cents per million B.t.u. per hundred miles, transportation figures suggest the following:

☐ Electric power transmission in 500- to 700-kw. lines is almost competitive with coal transport by unit train after allowance for conversion efficiency.

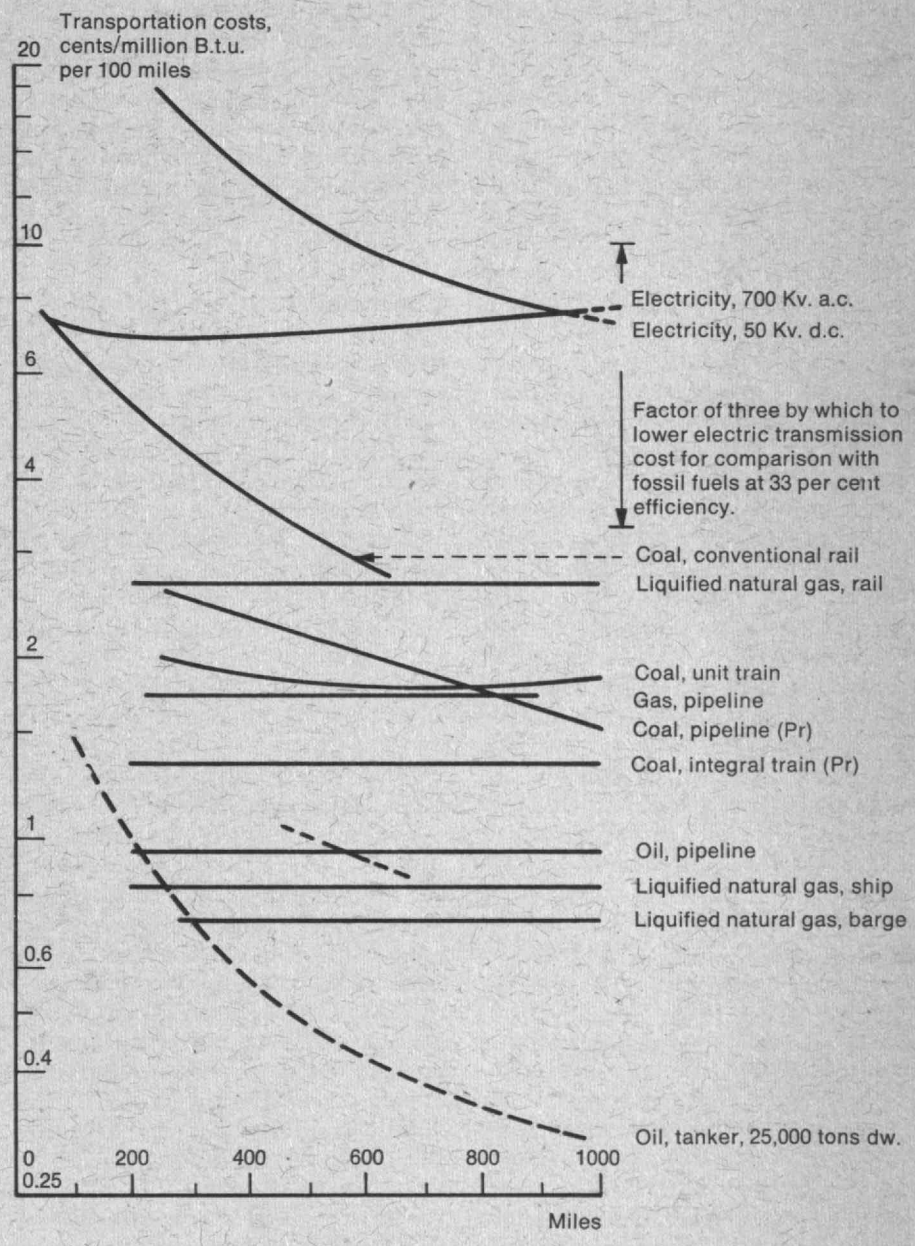
☐ Coal pipelines or integral trains could cut the costs of coal movement about 40 per cent. It has to be remembered, however, that railroads' flexibility and hence ability to institute new procedures are hindered by tradition, rate regulation, labor problems, and other management uncertainties.

☐ Coal pipelines or integral trains are almost competitive with gas in moving energy if allowance is not made for differences in efficiency of end use.

☐ The chief prospect for reducing the transmission cost of gas lies in the development of lighter and stronger pipe and improved pipelaying techniques.

☐ Oil pipelines can transport energy at one-third the cost of coal pipelines, integral trains, or gas pipelines.

☐ Pipelines have increased in size, but the associated scale economies in gas and oil transportation are so great that the nation's projected rapid growth in energy consumption will make still larger pipelines economically sound.



Though the chart above proposes to show comparative costs of transporting fuel and energy in different forms and by different means, it is in fact so simplified as to be only vaguely correct. For the actual transportation cost depends critically on the efficiency of the particular facility being considered as well as on the particular place and time when it is being used; for these reasons —and because parallel data are difficult or impossible to acquire—a critical issue in developing our energy strategies is only vaguely suggested by this presentation.

Sulfur Pollution

It is clear that combustion-generated sulfur dioxide (SO_2) may present a dispersion problem or a local pollution problem, but it is not a global pollution problem; the life of SO_2 is too short. It is estimated that by 1980 two-thirds of the total SO_2 emissions will originate from fossil-fuel

power plants. The sulfur-from-power-plants problem cannot be solved by use of naturally low-sulfur fuels; there aren't enough at economic shipping distance from point of use. Contrary to widely held public opinion, the pessimistic conclusions of a year ago of a National Academy of Engineering Panel concerning SO_2 removal from stack-gas still stand. This fact is documented and the various processes for sulfur removal through pre-combustion treatment of fuels and fuel-to-fuel conversion have been recorded by Arthur M. Squires elsewhere in this journal (*see "Capturing Sulfur During Combustion" in* Technology Review *for December, pp. 52-59*).

Thermal Pollution

The 1970 world rate of energy consumption corresponds to an energy release rate 1/6000 that of solar absorption by the earth. Thermal pollution is therefore not a global problem and cannot be for over a century. Local thermal water pollution, however, is a problem, chiefly associated with electric power generation, and issues in controlling emission of waste heat are discussed by Donald R. F. Harleman in his article in *Technology Review* (*see "Heat—the Ultimate Waste," in December, 1971, pp. 44-51*).

The Federal Power Commission estimates an increase in waste-heat dissipation from power plants from 5.3×10^{15} B.t.u. in 1970 to 28.4×10^{15} B.t.u. in 1990 (total energy consumption in 1970 was 69×10^{15} B.t.u.). Since the projected evaporation rate for wet-tower and cooling-pond operation will then be 0.8 per cent of the nation's run-off, extensive micrometeorological studies are warranted. Thermal water pollution at power plants can be eliminated by use of gas turbines or reduced by use of the gas-steam cycle (*see below*).

Energy Storage

Energy storage capability is not a major factor in present or future energy supply. In the field of storage battery development, marked superiority over lead-acid batteries has been achieved—in nickel-cadmium batteries, for example; but lead-acid continues to be better economically. High-temperature systems being developed—sodium-sulfur and lithium-chlorine, for example—are superior to lead-acid and claimed to be economically competitive; opinion is divided on whether the obvious containment problems associated with safety will be solved to the satisfaction of the public.

Pumped-water storage is beginning to be used for power-plant operation, with 10,600 Mw. planned as of December, 1969.

Thermal storage for flattening the load curve of electric space heating or for solar house design is best achieved with water tanks, crushed gravel bins, or concrete blocks (used in England); no good heat-of-fusion material that operates near room temperature has been found. Magnetite (magnetic iron ore) has an extraordinarily high volume heat capacity; a cylinder two feet in diameter and 12 ft. long raised 600°F. would store one day's space-heating requirements of a small house whose normal space heating requirement is 1,200 gal. of fuel oil per season.

Fossil Fuel-to-Fuel Conversion: Gas from Coal

There is strong evidence that the present 6 per cent per year growth rate in natural gas use will combine with continuously decreasing discovery rates of new gas to produce a great shortage of natural gas if both trends persist. The United States will need gas from coal at a time not yet established, but very probably soon, on a scale that will dwarf all other industry of comparable chemical content.

In consequence, the Office of Coal Research, the Bureau of Mines, and the American Gas Association are vigorously pursuing research on synthetic gas from coal. Four processes —two in pilot stage—deserve strong support; they have demonstrated sufficient promising results, freedom from serious faults, and differences in concept to warrant being kept in the running during the period of pilot-plant assessment of the processes. The four organizations involved are the Institute of Gas Technology, Consolidation Coal Co., the U.S. Bureau of Mines, and Bituminous Coal Research. The first two of these have pilot plants for the main gasification process near completion; the last two have plans for pilot plants and have done the necessary research.

In view of the magnitude of the final commercial operation based on the research of these four teams to date, the nation cannot afford to overlook the possibility that any one of the four processes may have advantages properly assessable only on a larger scale than that of the laboratory research which has been completed to date.

The analogous case in nuclear power plant development has been the retention, at great cost during the development stages, of at least five varieties of slow reactors and four varieties of breeder reactors, simply because the time lost in going back to a complex process abandoned in an early stage is too great. Viewed another way, a retention of four processes through sufficiently advanced stages to permit making a final choice of process that saves 10 cents per 1,000 cu. ft. in manufacturing costs will, in the days when our consumption of synthetic pipeline gas is one-third today's natural gas consumption, amount to a saving of $750 million a year. We cannot afford to decide prematurely on the wrong process.

The strong recommendation of continuation of four processes at least through the pilot-plant stage implies that much basic research has already been carried out on coal gasification, but it does not imply absence of the need for more. Any process that wins the race will be in need of continuous modification and improvement; and a strong research program, both basic and applied, on the physics and chemistry of coal gasification is needed.

The air-blown gas producer that left the American scene in the 1920's is due for a comeback if it can be made larger, automatic, and capable of handling coking coals, and if it can be given a high capacity through operation under pressure. A major impetus for developing a process for making low-B.t.u. gas from coal comes from the electric power industry. Producer gas made under pressure and scrubbed to remove sulfur is an ideal gas-turbine fuel; and, as Professor Squires pointed out in his earlier paper in this series, the combining of gas producers with gas-steam power cycles of high efficiency looks attractive as a solution to the sulfur problem in power production. The implications of low-B.t.u. gasification for power production are so striking as to warrant a more vigorous support of research on air gasification of coal at moderate pressures than at present exists.

The development of any process for producing synthetic crude oil could in the end well turn out to be primarily an insurance policy against excessive increase in the price of imported oil. But on this ground alone strong federal support of fuel conversion research is eminently warranted.

Conversion: Oil from Coal

Failure to couple the expectation that nuclear fuel will in the long run supply our power with the recognition that this cannot happen fast enough to eliminate the need for clean fossil fuels now is a real national danger; inadequate emphasis on research to produce clean fossil fuels both for power and for processing operations could produce an impasse between industrial energy needs and the need to protect the environment.

The various processes for making liquid fuel from coal are in too early a stage of development to allow meaningful estimates to be made of comparative costs. Processes which appear to be in the running include the H-Coal process, which uses a cobalt molybdenum catalyst to hydrogenate fine coal at high pressure in an ebullating bed, the Consol process modified to make low-sulfur synthetic crude oil, the PAMCO process for light hydrogenation of coal to make an ash-free product which is pumpable only when hot, and the COED process of staged pyrolysis to make gas, oil, and char. Opinions differ on the relative merits of these processes.

Research on H-Coal is being supported by a consortium of oil companies, and a National Academy of Engineering panel has recommended continued support of the Consol process. Though published studies of the probable cost of oil from coal have indicated the possibility of production of synthetic crude at prices comparing favorably with quoted market prices of crude oil, the estimates may not be realistic in their allowance for contingencies associated with new processes and for escalation during completion of development and plant construction.

Oil from Tar Sands and Oil Shale

The need for technological sophistication in recovering oil from nonpetroleum fossil deposits is much less when the raw material is tar sands or oil shale than when it is coal. This may cause earlier developments of oil from shale than from coal, regardless of ultimate comparative economics.

Tar sand treatment has become commercial in Alberta, on sands averaging 12.5 per cent bitumen. But oil shale is more attractive than tar sands to the U.S. oil industry largely because most of the good oil shale is in Colorado rather than in Alberta, but partly because the hydrogen-carbon ratio is higher. Three retorting processes have operated on sufficient scale (260-1,000 tons/day) to evaluate the retorting operation, and cost estimates appear reasonable; but experience with mining and acceptably disposing of shale at a rate in excess of one ton per second—the rate required in a plant producing 50,000 barrels of oil daily—is missing.

Comparison of Proposed Conversions

An intercomparison of the conversion processes considered—pipeline-quality gas from coal, low-B.t.u. gas from coal, oil from coal, oil from tar sands, and oil from shale—is difficult because of different objectives of different customers, national energy policy, foreign energy policy and import-pricing, differences in status of development of the processes, limits on ability to predict resources, the differences in cost-estimating procedures used in the economic studies, and the degree of interchangeability of the products.

Within the limitations these uncertainties impose, certain conclusions are possible. The shortcomings of stack-gas sulfur-dioxide clean-up systems so far investigated make processes for the production of sulfur-free fuels or for sulfur removal during combustion look especially attractive. Within this scope, two concepts—making clean low-B.t.u. gas from coal and making an ash-free, sulfur-free heavy hydrocarbon from either coal or oil—should be of great interest. If the cost estimates are realistic, completion of development along both lines is justified. Because of the capital-intensive character of fuel conversion processes, federal support is warranted on research on coal hydrogenation and on coal gasification with air, and on development of larger advanced-cycle gas turbines.

The resources of coal, tar sands, and oil shale are all so enormous as sources of oil that they must certainly someday be tapped. The timetable for this, however, is very difficult to establish, especially because of changes in import quotas and in prices established by foreign governments. On a comparative basis tar sands appear not to have as good a chance of early development as oil shale.

With respect to coal versus oil shale as sources of synthetic crude oil, the assessment is more difficult. Despite the considerable effort that has gone into oil-from-coal development, research processes for oil shale treatment are simpler and more nearly ready for use. But the yield from coal is so much greater (3 to 3.5 barrels per ton versus 0.8 barrel for relatively rich oil shale) and the disposal problem so much simpler that vigorous pilot-plant development followed by demonstration-plant operation is in the best national interest. The very fact that

the processing of coal to produce oil is considerably more complex than the production of oil from shale is reason to expect a greater improvement, through research, in the efficiency and cost of the latter.

The development of any of the previously discussed oil recovery processes to the point of producing synthetic crude at prices reasonably near present crude prices could well turn out to be primarily an insurance policy—but a very valuable one—against excessive increase in the price of imported oil. On this ground alone strong federal support of fuel conversion research is eminently warranted.

Priorities and Decision-Making

When it comes to making synthetic fuel from coal, shall we concentrate on producing a gaseous or liquid product? A technical affirmation popular today among engineers is that we need to do both, but gas from coal comes first because we are running out of natural gas. But the technological as well as the institutional factors involved are so exceedingly complex—depending not only on conversion technology and relative transportation costs but also on public utility price regulation, import quotas, and other artifacts of our political structure—that a well-grounded comparison will not be possible until pilot plants for gas and for oil have led to demonstration plants and the latter have been operated long enough to have reached near-optimization.

If we consider the billions of dollars per year hinging on the outcome of such a comparison, the need for large federal expenditures to develop clean synthetic fuels seems obvious. It is also true that the cheaper fuel will not necessarily win the race. Gas has advantages over oil which will offset a price difference (opposite in sign to the one existing today). As an aid to making more quantitative any comparison of gas with oil there is need for a comprehensive study of U.S. industry to determine the degree of interchangeability of fuel feasible at various cost differentials.

Related to the argument of the last several pages is the consideration of pipeline-quality high-B.t.u. gas versus low-B.t.u. clean gas, the latter either made locally by the plant needing it or made centrally for distribution to a group of local plants. Locally-made clean producer gas may in fact provide local industrial plants with gaseous fuel at a considerable saving over synthetic pipeline gas. This problem justifies a study similar to that on oil versus gas, to determine what markets would in the long run be better served by producer gas than by pipeline gas.

Nuclear Power

The technological and commercial success of nuclear reactors for power production is attested by the fact that at the end of 1970 a total of 20 operable nuclear plants contributed 2.2 per cent of the U.S. electric power generating capacity, and 89 more were being built or planned.

The projected growth in electrical energy consumption is so rapid that U.S. generating capacity, now 300,000 Mw., is expected to reach 1,500,000 Mw. by 2000; and nearly half that will be nuclear. The forms of these reactors and alternatives for their development have been described in this series by Manson Benedict (*see "Electric Power from Nuclear Fission" in* Technology Review *for October/November, 1970, pp. 32-41*). The cumulative consumption of uranium ore concentrates by the year 2000 (at the rate of 171 tons/1,000 Mw.-years) is estimated at 1.6 million tons, if breeder reactors have made no significant contribution by then. As Professor Benedict points out, the reserves are there—at a price; and this is the argument for developing the breeder, for the price of uranium would then be almost immaterial.

Thermal and radioactive pollution are of concern from light-water-moderated reactors—the kind used predominantly in the United States and in most other countries today. Thermal pollution is about 60 per cent greater, per megawatt of power, than from fossil-fuel plants. This means that most nuclear plants of the future will be located on the ocean or will be provided with cooling ponds or with wet or dry cooling towers. Escape of radionuclides from power plants and fuel-reprocessing plants is held to insignificant levels by multiple barriers. The major hazard of nuclear power-plant operation is associated with transportation of radioactive cargoes, particularly wastes going to processing plants in sealed stainless steel casks. The number of casks of spent fuel is expected to rise from 30 per year in 1970 to about 9,500 in the year 2000. By use of the Department of Transportation's overall rail accident rate of 0.3 serious accidents per million miles, an estimated 1.4 serious rail accidents per year involving radioactive shipments is projected for the year 2000 unless radioactive cargo shipments receive special rail handling. Proposed procedures for disposal of wastes in a salt bed in Kansas have been at least temporarily set aside, but no better general alternative has been suggested.

The ultimate need for breeders is unarguable. With respect to the urgency for their development, however, there is room for much disagreement. Doubling the nuclear fuel cost in the prebreeder era would permit the price of uranium ore to go up more than four-fold, since the fuel cost at the power plant is presently due one-third to ore and two-thirds to concentrating and cladding. The history of fuel-reserve projections is rich with underestimations, and uranium projections may not be exceptional. Uranium prospecting was vigorous a decade ago, but light-water reactors have not become available as fast as was anticipated and the pressure to find new ore is reduced.

Prospecting for certain types of uranium deposits such as pitchblende in igneous rock faults has not received the attention it deserves. The mining industry would be enormously stimulated to search if the price of crude uranium dioxide (U_3O_8) were, for example, increased fourfold in association with extended use of light-water reactors. Until there is a clear cost advantage of breeders over light-water reactors, independent of projected increases in uranium cost, the extent of the need for hurried development is no better established than is the knowledge of uranium reserves.

Three breeder concepts are being pursued, and if there is a question about the urgency of breeder development to commercial scale, there can also be a question about the timing of a choice among breeder types. Either a premature or a belated decision can be costly. Full-scale development involves a very large annual expenditure. After a decision has been made on which breeder to develop, a few years of costly developmental effort makes a change in path traveled nearly im-

How to reconcile the clear gain in living standards that would be associated with more energy use by the have-nots with the frightening consequences of untrammeled growth of energy consumption at the present annual rate for another half-century is, second to the world population problem, the biggest challenge of the 20th century...

possible. Hurdles that have proved to be nearly insurmountable will produce an increase in expenditure rather than a switch to another breeder concept. To wait, however, until all good nuclear physicists agree on which breeder to back would be absurd.

Based on its evaluations conducted up to 1969, the Atomic Energy Commission directs most of the available reactor development budget toward the liquid metal fast breeder reactor (LMFBR) program (over $100 million/yr.). The A.E.C. viewpoint is that resource requirements are such that the United States can afford to fund effectively only one concept, the LMFBR, by initial construction of two demonstration plants (with starts spaced about two years apart) to ensure that there will be more than one commercial manufacturer of LMFBR plants. However, funds are being made available to the A.E.C. for only one plant—a fact which supports the A.E.C. contention that resources are not sufficient to permit emphasis on more than one concept at this time. Supporting the other side of the argument—U.S. vulnerability in the event of technical-design and safety difficulties with the LMFBR concept—is the U.S. record in the reactor development area, which is replete with examples of failures to succeed in the development of promising reactor concepts.

The ultimate question is how the prospects for success of the LMFBR —including the short-term freedom from detrimental technical problems and the ultimate potential offered by its construction—compare with the projected ultimate potential of the alternatives—the gas-cooled fast reactor and the molten salt breeder reactor.

Central Power from Fossil Fuel

The generation of power from steam has had centuries of development and has reached what appears to be a plateau at a thermodynamic efficiency of about 40 per cent. Higher efficiency has been achieved, but there appears to be general agreement that steam temperatures much above 1000° F. are not economically justifiable.

However, the gas turbine-compressor combination is now being applied to various industrial uses, including peak-shaving in power plants. Stimulated by the ever-increasing demands for aviation propulsion power, the aviation industry is continuously raising the inlet temperature to the gas turbine and the compression ratio of the air compressor; and these improvements become available for use in stationary power plants. A recent study summarized briefly in this series (*see "Increasing Gas Turbine Outputs for Combined Gas/Steam Systems" in* Technology Review *for December, 1970, p. 60*) indicated that a gas-steam combination power cycle holds great promise for efficient generation of power from coal while simultaneously solving the sulfur pollution problem. The most impressive aspect of this work is that careful estimates, including allowance for thermodynamic losses, indicate that third-generation gas-steam plants of this type may achieve an efficiency from gas to power of 58 percent with a compressor-compression ratio of 36, a turbine inlet gas temperature of 3100° F., and transpiration cooling of the large blades that would be used in a 350-Mw. gas turbine. This result, combined with the efficiency of 87 per cent which has been suggested for a third-generation coal gasifier, suggests the possibility of an overall thermodynamic efficiency of power production from coal of 0.58 x 0.87, or 50.4 per cent before a small subtraction for auxiliaries.

Magnetohydrodynamic (MHD) techniques are also seen as possible for central-station power generation at thermal efficiencies of 50 per cent or higher. But MHD requires high temperatures (4000° to 5000°F.), the use of seed materials to promote ionization, and other troublesome conditions. The fundamental problems in MHD development—gas conductivity, seed recovery, and materials—remain unsolved despite more than a decade of effort by numerous competent research teams in several countries. Now added to these hurdles are problems introduced by environmental and fuel constraints, including nitric oxide formation in high concentrations and various effects of coal slag.

These obstacles leave little room for enthusiasm about the prospects for MHD development, especially since the contribution that it might eventually make—electricity from fossil fuel at a thermal efficiency exceeding 50 per cent—can be matched by gas turbine developments. The appropriate path to improving the prospects for MHD power generation is investment in fundamental, small-scale research in the problem areas mentioned.

The merits of superconducting electric generators for power-station use appear to be outstanding. Research of Professors Woodson, Thullen and Joseph L. Smith of the Electrical Engineering and Mechanical Engineering Departments at M.I.T., indicates that low-temperature operation of a power-plant alternator permits marked decrease in size, increase in power output, and decrease in unit cost.

Fuel cells convert the chemical energy of union of fuel and oxidizing agent, supplied at the electrodes, directly to electrical energy without fundamental limitations on efficiency such as those imposed on heat engines. The concept of supplying large-scale power by fuel cells has received attention because, in theory, fuel cells have potential for highly efficient fossil-fuel utilization with minimal effects adverse to the environment. In practice, however, they do not give the cost and performance characteristics demanded in commercial application. There is no indication that the outstanding problems involved in using fuel cells for central-station power production are close to solution or that significant advancement would result from large spending on research and development now. That should await more progress through small-scale, fundamental research.

Solar Energy Utilization

The emphasis on clean energy in recent years has caused much comment on the attractiveness of relying on the sun for power and heat.

Solar energy can be described almost completely by two numbers measuring quality and quantity. The quality of sunlight is such that its thermodynamic potential or theoretical maximum convertibility into work is extremely high. Said in still another way, a high fraction of the energy from the sun is in the form of shortwave radiation, capable of photosynthesis, of interaction with atoms and electrons in photovoltaic cells, or of coming to equilibrium with high-temperature receivers through suitable wavelength-selective filters. The other number of the pair that characterizes sunlight is the "solar constant" of 430 B.t.u./sq. ft./hr.—the energy rate on to a unit surface perpendicular to the sun's rays external to the earth's atmosphere. This implies that solar energy is extremely dilute; its flux density on to the earth is only 1/500th of that on to the surfaces of a modern steam boiler. Therefore, unlike most industrial process equipment, devices to intercept or collect solar energy benefit little by scale increase; solar energy is likely to find extensive use, if at all, in small units to accomplish individually small tasks.

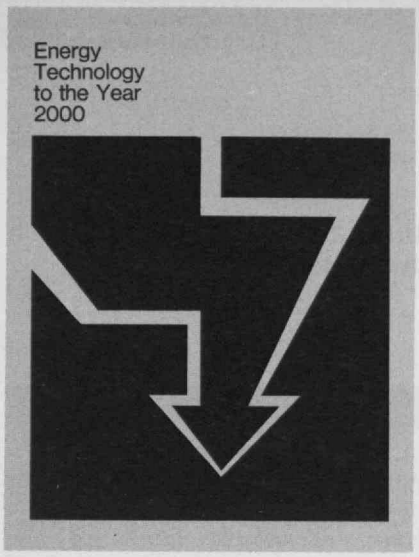
Domestic hot water from the sun is economically significant in many areas today; solar house heating is significant in some, and its prospects are improving; solar distillation to produce fresh water from saline water is economic in areas of extremely high fossil fuel cost; solar electric power from photovoltaic cells is significant in space research, where the laws of terrestrial economics are inapplicable, and it has some chance of becoming much cheaper. But in general one is forced to conclude that physical as well as photochemical use of solar energy on any moderately large scale is nature's way—not man's.

Optimized designs of solar house-heating systems for eight climatically different locations in the United States lead to the conclusion that, except for one location (Santa Maria, California), house heating with gas or oil is much cheaper than with solar energy. However, the growing use of electric space heating indicates that comfort is often not bought on a cost basis; and solar heating is cheaper than electricity in seven of the eight locations (Seattle-Tacoma being the exception).

Postscript

The fact that no comments have been made in this survey on whether man's appetite for energy should be whetted or curbed does not mean that no views are held on the subject. Learning how to use energy more effectively is unequivocably a good thing, and research directed toward improvements in efficiency of use is to be encouraged. Learning how to supply an ever-increasing per capita demand is a good thing within limits; we need to watch it. How to reconcile the clear gain in living standards that would be associated with more energy use by the have-nots—in the United States as well as in the rest of the world—with the frightening consequences of untrammeled growth of energy consumption at the present annual rate for another half-century is, second to the world population problem, the biggest challenge of the 20th century to our statesmen, economists, industrialists, scientists, and engineers.

Technology Review announces



"Energy Technology to the Year 2000"

Contents of "Energy Technology to the Year 2000":

"Energy, the Economy, and the Environment," David C. White, Ford Professor of Engineering, M.I.T.

"Electric Power from Nuclear Fission," Manson Benedict, Institute Professor (Nuclear Engineering), M.I.T.

"Geothermal – Earth's Primordial Energy," Richard G. Bowen and Edward A. Groh, Oregon Department of Geology & Mineral Industries

"Must Fossil Fuels Pollute?" Harry Perry and Harold Berkson, Congressional Reference Service, Library of Congress

"Heat – the Ultimate Waste," Donald R.F. Harleman, Professor of Civil Engineering, M.I.T.

"Capturing Sulfur During Combustion," Arthur M. Squires, Professor of Chemical Engineering, C.U.N.Y.

"The Quest for Fusion Power," Lawrence M. Lidsky, Professor of Nuclear Engineering, M.I.T.

"Creating Power Plants," William W. Lowe, Pickard, Lowe and Associates

"System Energy and Future Transportation," Richard A. Rice, Carnegie-Mellon University

"An Agenda for Energy," Hoyt C. Hottel and Jack B. Howard, Department of Chemical Engineering, M.I.T.

Now you may have in a single reference volume the 10 articles in Technology Review's "energy symposium" which concludes on the opposite page. An important addition to every reader's collection, this book is also an ideal gift for library or laboratory, an invaluable resource on the ultimate technological issues: How can our generators be powered? How can we use fuels and energy more efficiently? What shall we do with their wastes? Indeed, can world energy consumption continue its implacable increase?

To Technology Review, Room E19-430, M.I.T., Cambridge, Mass. 02139

Send me_____copies of "Energy Technology to the Year 2000" @ $1.95.

☐ Payment enclosed (books sent postfree)
☐ Bill me $1.95 each plus postage

Name

Address

Use a separate sheet to list gift orders.

Price, $1.95.
Use the coupon.

Write for discounts on quantities of 10 or more.

by Stewart W. Wilson
Senior Scientist,
Polaroid Corp.

Interactive Lectures

A new and remarkably simple communication structure is proposed to broaden interaction between teacher and student

One of the most natural ways for a human being to learn is to talk with a knowledgeable person—ask him questions, listen closely to the answers, and carry the conversation into directions which are personally relevant and important. Today, however, most people have few opportunities of this kind, since as knowledge and society have become more complex there are fewer people, proportionately, who can give good answers, and their time is in great demand.

Can we find some new way to extend this interactive experience to a great many more people than at present have access to it?

It would appear that, at least in principle, an interaction with an expert and responsive person might be approximated and made widely available through recording techniques. Yet the trend of technology's contribution to education has been in other areas: development of media and of more directive kinds of structures such as programmed instruction. In part, at least, this has occurred because it has seemed technically very difficult to create a system which would respond to questions and personal inquiry in a satisfyingly rich way.

Five years ago in this journal, Edwin H. Land and I reported an experiment in which a boy—typically about 13 years old—asked questions about atoms into a microphone and received answers which then served as take-off points for the next questions (*see "Education and the Need to Know" in* Technology Review *for January 1967, pp. 29-36*). We wanted to observe and understand the nature of a free-wheeling interaction which are person controlled, guided,—and could terminate—entirely in accordance with his own mind's requirements; and we wanted further to see if a person would engage in such an interaction, not with another person who was physically present, but instead with a set of responsive tape recordings. To investigate the latter point, we informed the students that the source of answers was a computer which could select from a large bank of tape. Actually, the answers each student received were given "live" by a person at the other end of the line.

The results of the experiment were exciting and encouraging. The sessions turned out to be surprisingly long—over one and a half hours on the average—and the questions were fascinating and often very challenging to answer. In fact, some sessions which ran to three hours or more had to be ended owing simply to the plain fatigue of the person at the other end. It was clear to us that each student valued and enjoyed an interaction of this type. But it was also apparent that the students had no difficulty in working with a system which to them was based on recordings. In fact, the boys' comments suggested that the decoupling between student and teacher which recordings allow had the effect of increasing their freedom to follow their own curiosity and interest.

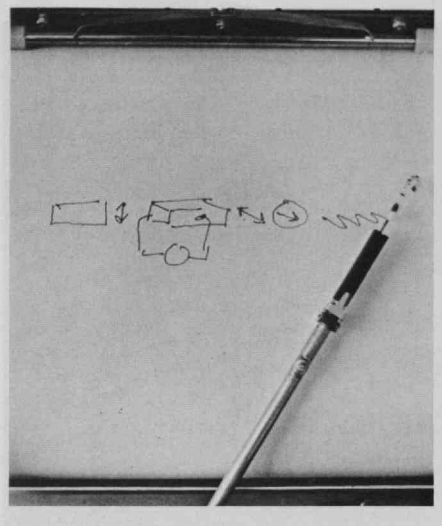
The challenge to me at that point was to find ways of making an interaction with responsive recordings—which of course we had only simulated—work. The problem was to answer a person's questions directly and well but to avoid a system whose stock of tapes tends toward infinity and whose access mechanism gets hopelessly complex. The many experiments since that time would make a long and possibly enlightening article on schemes which turned out not to be practical. But I came eventually to a rather simple recording structure which—as a consequence of the way the recordings are generated—is exceedingly practical and retains much of the variety and responsiveness of the interaction of our early experiment. In this article I describe the new structure, which I call an "interactive lecture," and present the results of experiments in which students tried it out.

Voice and Hand on Tape

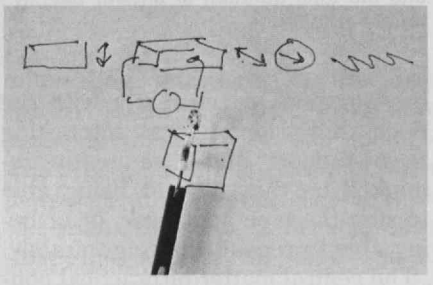
To explain what an interactive lecture is, it is helpful to relate the process by which the five interactive lectures which presently exist were each created. First, a professor was asked to record a talk on a scientific topic of general interest and also personal interest to him. The recording was a high-fidelity audio recording with Electrowriter sketches, made by the professor as he went along, recorded on the second track of the tape. In addition, the professor occasionally referred to photographs. I asked him to think of his talk as directed to an interested individual listener of college age.

The Electrowriter made it possible for the professor to illustrate what he was saying in much the way he would use a blackboard. The system has two units: a transmitter, on which the speaker writes with a pen on a roll of paper; and a receiver, in which a slender arm having a stylus reproduces the writing in ink on a similar roll of paper. The system is capable of a high degree of detail, and the receiver pen follows in exact synchronism the writing done on the transmitter, including hand gestures and pointing. In making the recordings the professor wrote or drew on the transmitter

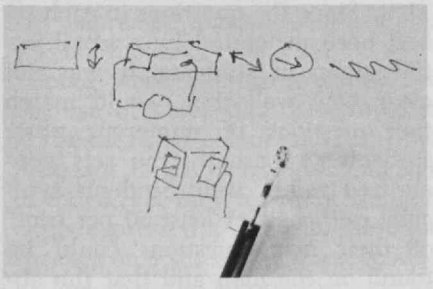
Part of an answer to a question on how laser light can be modulated for communication purposes. From a new interactive lecture on lasers by Stephen A. Benton, Assistant Professor of Applied Optics, Harvard University. *(Photos: Sheldon Lowenthal)*



". . . and then put a second polarizer so that the amount of output energy would depend on the amount of voltage on the crystal. This would be a transverse electro-optical effect."



"There's also a longitudinal electro-optical effect—the Pockels Effect—



"which uses transparent electrodes on the crystal's front and back surfaces and the light shines through them . . ."

whenever he wished; and its signal, together with his voice, was recorded on a stereo tape. On playback, the effect of this combination of voice and evolving drawings is remarkably engrossing and personal.

Next, the professor's talk—including the Electrowriter signals—was transferred to audio cassettes and made available for listening on a playback unit, including an Electrowriter receiver, in a comfortable private room. Duplicate prints of the professor's photographs were provided. A number of M.I.T. students, who took part voluntarily, then listened individually to the talk and in the course of listening wrote down questions which the material of the talk raised. The questions could be of any sort, not limited to those having to do with difficulties of understanding. Requests for background information, questions which took off from a point merely hinted at, challenges to the speaker's explanation, new directions resulting from new crystallizations in the student's mind—all were encouraged.

After several of these sessions the questions were collected and given to the professor for study. At his convenience, the professor returned and recorded individual answers to the questions (using the Electrowriter as appropriate). The style of his answers was direct and personal, as though each question had just been asked of him. The answers were transferred to cassettes, and these were placed with the cassettes containing the main talk. A new listener now had both the main talk and these answers at his disposal. He could have immediate answers to his own questions to the extent that they were similar to those for which answers had been recorded.

To gain access to the available answers, the listener used a 17 × 22 in. "map" of the interactive lecture, consisting of an outline of the main talk and a listing of all the questions, as related to each section of the talk, for which answers had been recorded. Once a particular answer (or section of the main talk) is selected, the listener is able by index numbers to find that answer—in about 10 seconds on the average.

Using the cassettes and the map, listeners continued to add new questions, some related to the main talk as before, and some related to the newly available answers. These questions were again collected, and answers to them were recorded by the professor. In all, five interactive lectures were made; in each case, as the chart shows, the amount of answer material exceeds that of the main talk.

To summarize, the making of an interactive lecture uses recording technology and an empirical method to discover and collect lines of inquiry around a given topic, so as to make them all available, at one time and place, to an interested individual. Though limited in range by comparison with the interaction of our early experiment, I hoped that an interactive lecture would nevertheless be a significant and useful step in the development of practical systems that were genuinely responsive to personal inquiry. I am deeply grateful to the five professors who made the recordings. Their willing interest, the quality of the material they created, and their delight at receiving excellent questions were a constant encouragement to me.

Using Interactive Lectures Interactively

The major experimental period began after the interactive lectures

were completed. Forty-eight M.I.T. students came over a period of four months to try the lectures in response to advertising in the student newspaper. The ad listed the titles and authors of the lectures and briefly mentioned that the recordings included answers to questions. The students who came were approximately equally distributed from freshmen to graduate students. All five interactive lectures were available to a student, and he could spend as much or as little time as he wished in each of as many sessions as he wanted. After a session, he was informally interviewed for his comments. The students were also invited to jot down any new questions which might occur while listening.

Since this was an exploratory experiment, and was necessarily conducted in informal circumstances, the results most naturally take the form of observations on student reactions. A significant quantitative result, however, concerns the length of time each student spent per session with the recordings. For the 48 students, the mean session time was 2.1 hours (averaged over the mean times for each student). Nine students had mean times of 1.5 hours or less; 16 had mean times of 2.5 hours or more. Upon emerging from a session, students occasionally expressed surprise at the amount of time which had passed.

There was a rather close correlation between a student's background and interests, as indicated by his major course of study, and the particular interactive lectures which he chose to hear. For instance, students in physics would invariably want the cosmology recordings, while students in biology would usually select the recordings on the symbiotic theory and on the origin of life. Most students did not choose interactive lectures whose topics were relatively unrelated to their major fields. Most of the students who responded to the advertisement (in which the topics were listed) were matched, in the above sense, to at least one of the interactive lecture topics.

From their comments, I found that students generally used the interactive lectures "interactively"; that is, they stopped frequently as they went through the lecture to hear answers to related questions. Twenty-five of the students wrote down new questions. A few students at first used the recordings in a more conventional way: they listened primarily to the main talk and returned to questions only at the end of the session. In later sessions, however, these students said they began to use questions concurrently with the main discussion. It was interesting that students quite frequently remarked on the value of being able to stop the tape and think, or of being able to repeat a passage exactly.

The central matter of practical concern was whether the students felt the sets of questions with the interactive lectures to be sufficiently complete. Since the questions in each set had been generated by a small initial group of students, it was not clear how well they would match the questions of numerous other students. Apparently the sets generalized rather well. Students typically said that "at least 50 per cent" of their own questions could be found on the map and that the absence of the remaining percentage was not limiting. Some students mentioned that it was nice to see

Interactive lecture (title and lecturer)	Length of main talk (minutes)	Number of questions	Total length of answer material (minutes)
Cosmology Philip Morrison, Professor of Physics, M.I.T.	166	49	203
Implications of The Apollo 11 Lunar Material John A. Wood, Smithsonian Astrophysical Observatory	45	32	124
The Symbiotic Theory of the Origin of Higher Cells Lynn Margulis, Assistant Professor of Biology, Boston University	59	36	92
Experiments on the Origin of Life Carl Sagan, Professor of Astronomy, Cornell University	62	29	88
Leaf Insects, Birds, and Human Color Vision Jerome Lettvin, Professor of Communications Physiology, M.I.T.	39	21	76

The five interactive lectures listed above were made during the course of the experiment described by the author. The table shows for each lecture the duration of the main talk, the number of questions, and the total duration of answer material available.

On the two following pages is the "map" (rearranged somewhat for the *Review*'s format) of an interactive lecture on the geological analysis of lunar material prepared by John A. Wood of the Smithsonian Astrophysical Observatory. Questions related to a particular section of the main talk (center column) are grouped together on the "map" next to the corresponding main-talk section. Both main talk and answers are indexed so that the student can easily go to any part of the talk or any answer he seeks; in the typical two-part index number, the first number refers to the cassette, the second to the "band" in that cassette.

The console used by students in the experiment, with cassette deck, speaker, Electrowriter, and an album containing cassettes for one of the interactive lectures. *(Photo: Sheldon Lowenthal)*

interesting questions on the map which might not otherwise have come to mind. There was no difficulty in adjusting to the particular language of a question as stated on the map. However, it became clear that the answer on tape should closely match the question on the map; that is, the question as stated should indeed be answered, and rather directly. Students occasionally expressed annoyance when this was not the case.

There were interesting results on the use of voice plus Electrowriter as the means of communication from professor to student. This is an age of video, yet only a few of the students expressed a desire to view the speaker on a screen. The rest tended to feel that the information gained from seeing the speaker would not be worth the added expense and might even be distracting. The voice/Electrowriter combination, on the other hand, was found by many students to be surprisingly effective —and also personal. This was due, to judge from their comments, to the engaging nature of the Electrowriter drawings, to the fidelity of the voice recording, and to the individual feeling with which the main talk and the answers had been recorded. In fact, several students specifically remarked how, on playing back the answer to a question, they could easily imagine that the professor was present in the room, answering directly. (Conceivably, an image of the speaker might lessen the feeling of personalness, since it would suggest an interposed camera and another location.) About half of the students thought that some additional subject-related visual material (in the form of photographs or film-loops) would be useful in connection with certain sections of the recordings; the other half did not feel an insufficiency in this respect.

A True Course for Educational Technology

I found that students enjoyed using the interactive lectures and valued the experience primarily because they had gained new information and understanding on topics of interest to them. There were numerous suggestions that an easily accessible library of recordings in the interactive format would be a useful resource at school. Some students felt that interactive lectures would be a desirable substitute for regular lectures. But all of them believed that the best use would be in the form of a large and diverse library to which any student could go to learn a lot about a topic of personal interest in a relatively short time, and do so directly from an expert in the field. The students also suggested that an interactive lecture would be good background for personal discussions with the professor who had made it.

The results of this experiment may perhaps be summarized and interpreted by the following model. The students who came did so out of intellectual interest in one or more of the topics offered. The sessions were long as a consequence of this basic interest and also because the interaction permitted a student to tailor his use of the recordings to the things of greatest particular interest, and had a personal quality. Because the recordings were responsive to the students' intellectual requirements, a large amount of visual material—beyond that needed for informative purposes—was not essential.

Implications of the Apollo 11 Lunar Material

by John A. Wood
Smithsonian Astrophysical Observatory

Dr. Wood tells how his group has worked with sixteen grams of Mare Tranquillitatis *and come up with a new hypothesis about the structure and early history of the moon:*

You seem to be skeptical about the value of the quarantine procedure. Would you explain why? (7 minutes) 3/1

What is the present schedule of future Apollo missions? 3/2

How would you assess the value of the Apollo program in relation to its cost? 3/3

How is the age of a rock calculated from its radioactivity? 3/4

Was there actually any significant probability of finding fossils or organic compounds on the Moon? 3/5

You mentioned that some people were looking for diamonds in the sample. Where would they have come from and how would they have been formed? 6/4

What is "petrology"? 6/3

Introduction; distribution of the lunar sample to various groups 1/1

The terrain at Tranquillity Base; diffusion of impact debris 1/2

How is the depth of the regolith determined? 3/6

Why is it believed that the regolith is deeper in the highlands than in the maria? 3/7

Why does the Moon's escape velocity set a lower limit to the speed of incoming meteorites? 3/8

Why did the fine lunar dust stick to the rocks? 4/4

Appearance of the sample material: preparation of thin sections 1/3

The four basic types of rock present:

Basalt 1/4

Anorthosite, glass, soil breccia 1/5

What might be the meaning of the high titanium content of the lunar material? 4/5

How does the chemical analysis of the sample compare with analyses of Earth material and material from meteorites? What questions is one trying to answer, and what do the results tend to say? (7 minutes) 8/1

It was mentioned in the newspapers that the glass which was found might be the result of some special astronomical event. Do you think so? 4/6

What was it about the glassy layer that led most people to conclude that Prof. Gold's idea was probably not correct? 7/2

What is a "degradation product"? 6/5

The sample as a key to lunar structure and thermal history:

Significance of the anorthosites 2/1

How did the Surveyor 7 alpha-particle backscattering experiment work, and what composition did it find? 4/1

Would you show the calculation by which it is estimated that the Moon's crust is 25 km thick? 4/2

How is the overall density of the Moon determined? (7 minutes) 4/3

Can you really be sure that the highlands are composed *mostly* of anorthosite? That seems a critical step in the discussion. 8/4

A structural model of the Moon; formation of the maria 2/2

What can one say about the fact that all the maria are on one face of the Moon? 4/7

If the maria were made by huge meteorite impacts, where are those meteorites now? They were certainly too big to have been annihilated. 8/5

What do the results of Apollo 11 and 12 imply about the way the Moon formed, and what, in general, are the major theories? (10 minutes) 6/2

You said that the great density difference between the Earth and Moon was pretty decisive evidence against the accretion hypothesis. But it seems to me just the opposite, namely, that the iron would tend toward the central body, leaving the lighter material to form the Moon. Why would this not be the case? 7/3

Would you comment on particle accretion in general? Does the theoretical problem lie in getting the particles to come together in the first place, or in their staying together, or in their ultimately fusing, or what? (5 minutes) 8/3

In several places you speak of "tidal interactions" between the Earth and Moon. Just how does one body twist or flex the other? (15 minutes) 7/1

If you could be placed on the moon with a complete lab, what would you do first? 7/4

Formation of the crust by magmatic fractionation; implication that the Moon was once very hot 2/3

What do you mean by "refractory"? 4/8

Did the radioactive dating give any indication of when this molten or volcanic period of the Moon ended and is there any indication that there is still some volcanic action going on? 8/2

What is the basis for Professor Urey's belief that the Moon has always been cold? (5 minutes) 5/1

If the Moon was once hot, what was the source of heat? (8 minutes) 5/2

What do your results on early heating say about the Moon's origin? 6/1

If this interpretation is correct, the experiment with interactive lectures suggests that technology's deepest contribution to education should occur not so much in the programming of instruction, or even the further development of media, but instead in the creation of individually responsive systems. From a practical point of view, such systems, to be useful and satisfying to people, have been thought—at one time by me, as well—to require large information networks and the consequent use of computers. But the present experiment indicates that size is not so important if the material is generated by the right technique. Although each interactive lecture had only a finite set of answers to questions, the students did not find this finiteness limiting; nor did they find the listed questions inappropriate. The essence of creating a responsive system of deep fascination may lie in finding knowledgeable speakers, applying good initial questioners, capturing the results on tape, and then providing good maps.

Toward Interactive Learning Centers

What might be the meaning of this experiment for universities? I suggest that the experiment responds to two increasingly felt needs: for closer individual relationships between students and faculty; and for new opportunities and resources through which a student can do a significant part of his learning on his own. The two aims are connected, since the more effective a student can be in teaching himself, the more time both he and a professor will have for the kinds of relationships in which personal contact is most fruitful. A library of interactive recordings should offer important new opportunities for independent learning, but at the same time it should have the perhaps unexpected effect of increasing in both degree and dimensions the direct contact between student and professor.

I can envision a conveniently located center where interactive recordings on a great many topics are readily available to all students at any hour. A freshman, for instance, who was curious about lasers could come during two free hours and learn from an interactive recording which would link him, in effect, with one of the institution's foremost teachers in the subject. Or a senior, interested in a new field whose results were still scattered in journal articles, could connect with a person who knew and had assimilated those articles—perhaps also written some of them—and could put the results, and their relative importance, in perspective. Another student might choose an interactive recording on an older but never easy theoretical subject such as relativity and he would learn through the clarity, expression, and responsiveness to questions of a teacher who, having lived with those questions, understood the subject deeply. The first activity of the center, then, would be to act as an impedance-matcher between a student who desires to learn a certain thing and an expert and responsive person who knows that thing well.

But the very fact that the impedance match was a good one would lead quite naturally, I believe, to the student's seeking out the professor and talking further to him personally. The door of a professor's office is always open, but part of a student's problem in crossing its threshold is that he often has had little previous interaction with the professor and it is hard to know where to start. The discussion usually begins with the last quiz, because that is something the two have in common. But it instead they had the common experience of an interactive recording, I think this kind of obstacle would disappear. The student would, in a very important sense, know the professor; and the discussion could begin with the new directions and unanswered questions the recordings had inspired.

The center's second activity would be the creation of new interactive recordings. In this, the participation and contribution of students would be essential. New topics and speakers would be chosen according to students' expressed interests, and small groups of students would associate with each professor in the generation of each set of recordings. This would seem to me a participatory experience of a high human and intellectual order. The students' responsibility would be independently to discover in themselves questions which even as they led to new understanding also brought out the professor's talent and power—indeed, his inherent greatness—as a teacher. And the professor's complementary responsibility would be to put his knowledge and experience, in the subjects he knows best, at these students' disposal. This special kind of interaction would be an exciting and rewarding enterprise in itself. But it would have special reward because it would have a creative product—a set of recordings—that many others will use and enjoy.

The third activity of the center would be research. I have used the term interactive recordings in the last few paragraphs because I sense that there must be a whole family of

To illustrate what he is saying during recording, the speaker—in this photo the author—picks up the Electrowriter transmitter's pen and writes. (*Photo: Sheldon Lowenthal*)

useful formats of which the interactive lecture is just one member. As an example, one might consider generating recordings by beginning with a small set of fundamental questions, letting their answers lead to further questions, and building a kind of mosaic. Differences in topic and degree of formality should probably lead naturally to differences in form. The research would also include developing new interactive technology and testing new devices experimentally with students to find those that make the interaction work best. For example, it is possible that an interactive recording implies a basically new kind of storage and play-back design.

All these activities would take place concurrently in the center, in an atmosphere of participation and intellectual enterprise. Because it would be fundamentally concerned with questions—with discovering real questions and responding excellently to them—I believe the center would enjoy a fresh, unifying, and constantly revitalizing spirit. It would have questions as its focus, and it would bring the talents of many people directly to bear on understanding and exploring this most basic expression of the need to know.

My work began with and has been sustained by the belief that the question-answer mechanism is intuitive to the human mind and must therefore flourish and find continual response in our society if that society is to continue to consist of capable, creative, and responsive individuals. We cannot afford to forget, as society ages and becomes more complex, that every civilized advance and every increment of personal growth begins with a question. In my work I have attempted to understand the dimensions of the question-answer mechanism and to discover structures which, in harmony with the nature of that mechanism, would permit its exercise to be real and wide-spread. I offer for consideration one such structure which, to me and to the students who have tried it, works and feels right. Its value and promise are far from fully explored, and to do so will require the interest, competence, and energy of many people. But this enterprise, in which culture and technology converge, should be a joyful and refreshing one because the goal and the need are so deeply human.

by Richard A. Carpenter, Chief
Environmental Policy Division
Congressional Research Service
Library of Congress

National Goals and Environmental Laws

Our sudden concern over environmental quality has acted as a political shock wave—bringing reorganizations and new agencies to the executive branch, changing the ingredients of equity in judicial decisions, and rattling the windows of every office on Capitol Hill. There is, of course, a hard factual basis to the new emotional perception of environmental impacts; the problems exist, and they are serious. Indeed, the passing of superficial faddishness about the environment will leave a residue of stubborn serious problems for society.

Our current problems all arise out of the exponential increase which is revealed in the growth curves, soaring toward the vertical, of practically any measured value of civilization when plotted against time. No matter where we turn we are looking at a steep slope. The rates of population growth and technological change are added together to produce drastic demands on finite resources and on a biosphere geared to the leisurely pace of evolution.

For example, the Committee on Resources and Man of the National Academy of Sciences reports that to accommodate the population by the end of the century, the developed world will require additional urban facilities equivalent to all those already in existence—and correspondingly more for the developing countries. The report of the M.I.T. Study of Critical Environmental Problems (S.C.E.P.), *Man's Impact on the Global Environment,* reports the worldwide annual rate of increase of materials flow in a few industries: agricultural production—3 per cent, mining—5 per cent, industry based on farm products—6 per cent, industry based on minerals—9 per cent, construction and transportation—6 per cent, and commerce in general—5 per cent. All these rates exceed the most fundamental increase of all—worldwide population growth of 2 per cent per year.

The world gross domestic product grows at 6 per cent per year—doubling in just 12 years. But North America, Europe, and Russia—with only one-third of the world's population—account for 84 per cent of the total gross domestic product. A citizen of the developed nations commands up to eight times the resources of a native of a less developed country. Thus the ecological demand is to a great extent concentrated around the North Atlantic ocean, and this geographical imbalance adds to the impact of exponential growth.

This is what has sneaked up on us, and it is why we must respond quickly if we are to retain purposeful management of our affairs. The question is whether our institutions of democratic free enterprise are responsive enough to achieve effective decisions for our society. (It is worth noting that socialist systems have reached the same stage of pressure: Marshall I. Goldman wrote in *Science* for October 2, 1970, that the U.S.S.R. senses a problem of "environmental disruption that is as serious as almost any that exists in the world." So this question is now of equal importance: Can international management work on a global basis—since much of the environment on which we all depend is in fact a "world commons" of the atmosphere and ocean?)

A Rational Legislative Basis

The crux of the issue are the conflicts and choices among natural resources, environmental services, and amenities. The historic goals of growth, power, wealth, consumption, progress, and security are being challenged. In the extreme, we are urged to replace them with those of the new "zero" school—zero population increase, zero economic growth, zero risk, zero technological change.

My thesis is that our goals have never been as simplistically exploitive as we now tend to think, that our laws reveal a continuing quest for balance and for optimum resolutions of conflicts between resources and needs. Man does manage the environment in his own self interest. Any other premise denies history and human nature. It is the continual redefinition of interest which is important and which must be allowed for by flexible legislation.

The rational bases for these political expressions are found in the principles of natural science and economics, tempered by the realities of our pluralistic system of politics and conventional wisdom. Ecology is the integrating discipline through which biological axioms—including many important new ones—are being brought into the complex rules for environmental management. As we learn more and more about the interdependence of man and his biosphere, we find our policies and practices in conflict. But the political process for resolution of such conflicts between goals and practice in the United States continues to work toward optimizing the management of the environment for both productivity and quality.

The Intent of the Congress

A look at U.S. law shows some of the policies which guide environmental management in this country; each was adopted with considera-

Environmental protection has always rested in the U.S. more in ethic than in contradictory or absolute legal restraint. The author argues for maintaining this tradition.

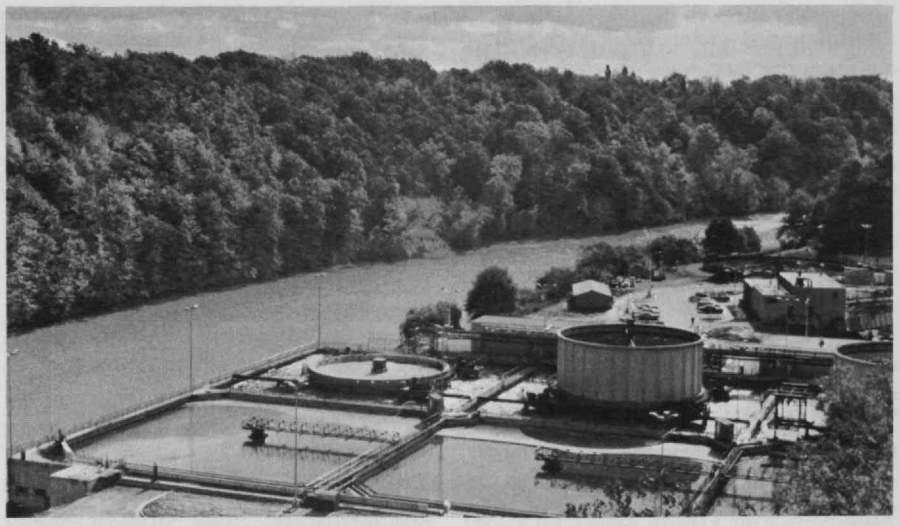
tion for prudence and expediency in gaining social benefits. Each of our laws was written to deal with individual and often narrow environmental sectors, and so it should be no surprise that they occasionally conflict with one another. Indeed, in the light of today's knowledge and in consequence of change made possible by technology, it becomes apparent that our laws are often internally inconsistent.

For example, the National Park Service Act of 1916 was passed to promote and regulate the use of national parks, but it also contained this statement of the purpose of these Federal areas: "To conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations."

Even the Wilderness Act of 1964 contains an instance of the "have your cake and eat it too" syndrome: Areas designated as a part of the National Wilderness Preservation System "shall be administered for the use and enjoyment of the American people in such a manner as will leave them unimpaired for future use and enjoyment as wilderness. . . ." Clearly, technology has brought such affluence, leisure time, and mobility to our society—and thus increasing interest in the use and enjoyment of nature—that unimpairment is now difficult to reconcile with the millions of citizens who wish to visit wilderness areas. A trip through many of our national parks and monuments this summer would provide ample evidence of the conflict in these instructions.

Public Law 91-631 passed recently by the Congress sets forth a new minerals policy declaration which emphasizes both the desirability of further expansion of the minerals industry and the need to protect environmental values (Sec. 2): "The Congress declares that it is the continuing policy of the federal government in the national interest to foster and encourage private enterprise in (1) the development of economically sound and stable domestic mining, minerals, metal, and mineral reclamation industries; (2) the orderly and economic development of domestic mineral resources, reserves, and reclamation of metals and minerals to help assure satisfaction of industrial, security, and environmental needs, (3) mining, mineral, and metallurgical research, including the use and recycling of scrap to promote the wise and efficient use of our natural and reclaimable mineral resources, and (4) the study and development of methods for the disposal, control, and reclamation of mineral waste products, and the reclamation of mined land, so as to lessen any adverse impact of mineral extraction and processing upon the physical environment that may result from mining or mineral activities."

For the Forest Service, the Organic Act of 1897 named water and timber as the resources for which the national forest were established—"to furnish a continuous supply of timber." The Multiple Use—Sustained Yield Act of 1960 stated: "It is the policy of the Congress that the national forests are established and shall be administered for outdoor



The author contends that American goals have never been "simplistically exploitive," that our laws "reveal a continuing quest for balance;" today's emphasis on environmental issues is but a way station in the evolution of our relationship to our planet. The pendulum's swing now seems rapid, however: "overt pollution is not defensible in the present climate of opinion." A typical response is this $10 million plant at Rochester, N.Y., where up to 36 million gallons a day of Eastman Kodak Co.'s industrial waste water can be treated before its return to the Genesee River. (Photo: Eastman Kodak Co.)

recreation, range, timber, watershed, and wildlife and fish purposes. The purposes of this Act are declared to be supplemented to, but not in derogation of, the purposes for which the national forests were established as set forth in the Act of June 4, 1897."

The theory of multiple use is now taken as a starting point in many land management controversies—in, for example, the justification of dams by the Corps of Engineers, the zoning decision of urban planners, and the setting of water quality standards. But multiple-use is not helpful in setting priorities or resolving conflicts. The Public Land Law Review Commission wrote in a recent report, " 'Multiple use' is not a precise concept. It is given different meanings by different people, as well as different meanings in different situations. We have listened to statements from diverse interests who all commended the idea of multiple use, but it was apparent that they were supporting different basic positions. This confusion permeates public land policy.

"We recognize that nearly all public lands are capable of producing a variety of values, but we do not believe that this means that these lands are necessarily managed for multiple purposes. It is also our belief that multiple use has little practical meaning as a planning concept or principle. We do, however, believe that the term can be used meaningfully in a descriptive sense to describe the operation of present public land policy under which (1) national forest and unreserved public domain lands are managed for a variety of goods and services, and (2) the administrative agencie determine which use shall be made of the lands in each situation, since no statutory preference is specified."

In the example of the national forests it should be noted that the title itself sets up a potential conflict: "The Multiple Use—Sustained Yield Act." As defined in the Act, sustained yield means "the achievement and maintenance in perpetuity of a high-level annual or regular periodic output of the various renewable resources of the national forests without impairment of the productivity of the land."

Implementation of the Laws

Beyond the preamble rhetoric of goals lies the working language for administration. The present water pollution control legislation (P.L. 91-224) and the controversial amendments now before the Congress illustrate the provisions for balanced implementation. Called "safeguards" by some and "loopholes" by others, these operational phrases are interpreted in real world specific situations.

The existing law states: "Standards of quality established pursuant to this subsection shall be such as to protect the public health or welfare, enhance the quality of water and serve the purposes of this Act. In establishing such standards the Secretary, the hearing board, or the appropriate state authority shall take into consideration their use and value for public water supplies, propagation of fish and wildlife, recreational purposes, and agricultural, industrial, and other legitimate uses."

If discharges occur which violate the standards in interstate or navigable waters, the federal government may institute abatement action by suit or by injunction. The law gives these instructions: "The court, giving due consideration to the practicability and to the physical and economic feasibility of securing abatement of any pollution proved, shall have jurisdiction to enter such judgment, and orders enforcing such judgment, as the public interest and the equities of the case may require."

The new amendments seek to combine the discharge permit system of the 1899 Refuse Act with a definite time table for effluent control. The widely publicized declaration of policy states: "The objective of this Act is to restore and maintain the natural chemical, physical, and biological integrity of the Nation's waters. In order to achieve this objective it is hereby declared to be national policy that consistent with the provisions of this Act—(1) the discharge of pollutants into the navigable waters be eliminated by 1985 . . ." Reaction to this goal of restoring a pristine state has generated the label of "1491 Standard" (pre-Columbian). However, a more careful reading of the bill and the important Senate floor debate reveals instructions for administration to "require the application of the best practicable control technology currently available . . ." and if ". . . compliance is not attainable at a reasonable cost, in which event there shall be applied an effluent limitation based on that degree of effluent control achievable through the application of the best available technology, taking into account the cost of such controls. . . ."

During floor debate, Senator Muskie said, "Reasonable cost is the basic test, under the pending bill, for eliminating discharges."

Senator Buckley interpreted a "rule of reason" into the Act where "the next standard would not be implemented if the social and economic

The Swampland Acts of the mid-nineteenth century were designed to recover fertile acreages for agriculture. Now we are determined to preserve coastal zones, estuaries and wet lands . . .

costs clearly out weighted the social and economic benefits."

If these new amendments are adopted, there will still be leeway and flexibility to reflect the public's willingness to pay and its dedication to environmental quality. Adjudication of the law is an important means of ascertaining the balance of goals.

Court action is reached only after a long series of hearings and investigations. In the past few years considerable abatement has been motivated by the public exposure of polluters through this process. Gross, obvious, and overt pollution is not defensible in the present climate of opinion. However, a recalcitrant business or community can look to the letter of the law and bring the sequence of criteria, standard setting, emission control, and abatement enforcement to the point of judicial decision. Thus the final outcome of a hypothetical struggle between a stubborn polluter and a zealous enforcement agency depends on the interpretation of value words such as enhance, practicability, economic feasibility, and equity.

Complementing these laws, which are seeking to regulate the private-sector use of the air and water commons, is the National Environmental Policy Act. Section 102(2) (c) requires all federal departments and agencies to "include in every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment, a detailed statement by the responsible official on (1) the environmental impact of the proposed action, (2) any adverse environmental effects which cannot be avoided should the proposal be implemented, (3) alternatives to the proposed action, (4) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and (5) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented."

The Act carries no authority for prohibition of an activity even if the impact statement should present an unattractive cost-benefit analysis. It simply creates a new and more complete fund of information for decision-making by the President, the Congress, and the public, for these reports are all to be available for inspection. It is in fact such elucidation of the consequences of technological change that offers the best chance for conflict resolution.

The National Environmental Policy Act in its declaration of policy in Title I makes clear the dichotomy in legislative language by calling on the federal government "to create and maintain conditions under which man and nature can exist in *productive harmony* . . ." (emphasis added).

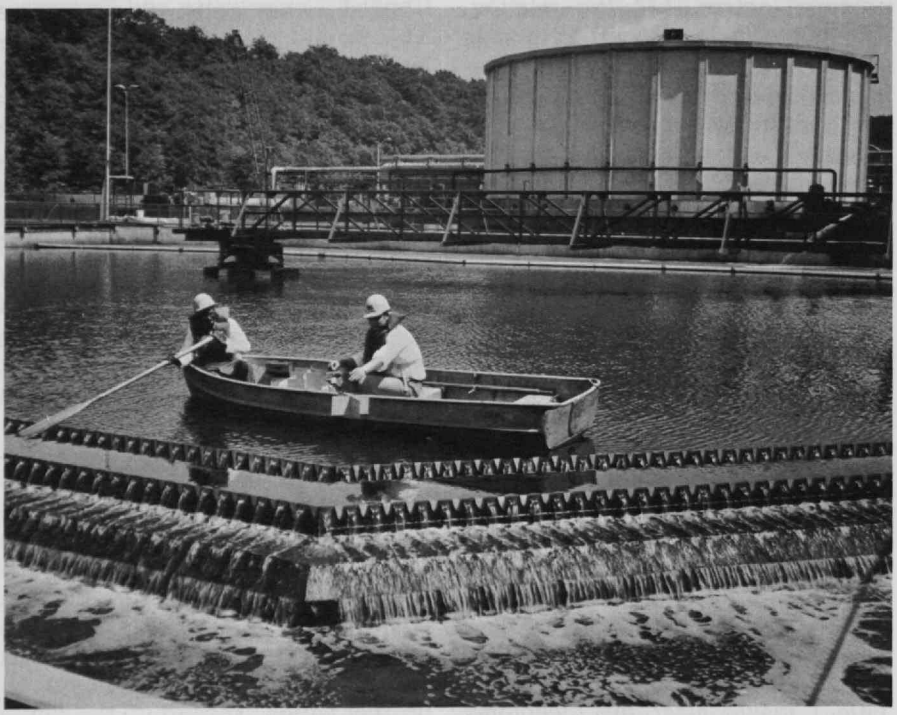
This continuing quest for balance has been written into operating instructions for the Environmental Protection Agency. Last year the Senate-House conference report on appropriations for E.P.A. stated: "The conferees, therefore, direct that, in addition to the environmental effects of an action, all required reports from departments, agencies, or persons shall also include information, as prepared by the agency having responsibility for administration of the program, project, or activity involved, on the effect on the economy, including employment, unemployment, and other economic impacts."

Conflict, Compromise, and Progress

The production of electric energy leads to environmental consequences which give this goal-derived conflict first priority in 1972. The legislation establishing the Federal Power Commission in 1920 stated "the purpose of assuring an abundant supply of electric energy throughout the United States with the greatest possible economy and with regard to the proper utilization and conservation of natural resources." This almost incidental reference to the environment may be contrasted with the provision in the Electric Power Environmental Policy Act of 1970 (introduced but not enacted as yet) "that such bulk supply facilities be constructed, operated, and maintained in a manner adapted to assuring a safe, healthful, productive, esthetically and culturally pleasing environment for all of the nation, including the preservation of important historic, cultural, and natural aspects of the nation's heritage."

The current preoccupation with restating goals is perhaps epitomized by the language of the Full Opportunity and National Goals and Priorities Act (S.5) which passed the Senate in 1970: "to promote and encourage such conditions as will give every American the opportunity to live in decency and dignity, and to provide a clear and precise picture of whether such conditions are promoted and encouraged in such areas as health, education and training, rehabilitation, housing, vocational opportunities, the arts and humanities, and special assistance for the mentally ill and retarded, the deprived, the abandoned, and the criminal, and by measuring progress in meeting such needs."

Many other examples of conflict



There is no absolute standard of cleanliness in present federal water-control legislation; the final outcome of any struggle between a polluter and an enforcement agency, says the author, "depends on the interpretation of value words such as 'enhance,' 'practicability,' 'economic feasibility,' and 'equity.' " But quantitative measures of water content and basin settlings enter into such judgments. (Photo: Eastman Kodak Co.)

could be cited. The Swampland Acts of the mid-nineteenth century were designed to recover fertile acreages for agriculture. Now we are determined to preserve coastal zones, estuaries and wet lands, realizing their role as nurseries for much of the ocean fisheries. The Appalachia bill provides for the accelerated construction of dams, roads, reservoirs, and other public works as immediate employment sources and the ingredients of economic growth while acknowledging the need to protect the esthetic and recreational values of that unique region.

But perhaps the most dramatic change in public policies can be seen in two landmark laws, a short quarter century apart in time. From the Employment Act of 1946: "The Congress hereby declares that it is continuing policy and responsibility of the federal government to use all practicable means consistent with its needs and obligations and other essential considerations of national policy . . . to promote maximum employment, production, and purchasing power." And from the National Environmental Policy Act of 1969: "The Congress, recognizing the profound impact of man's activity on the interrelations of all components of the natural environment, particularly the profound influences of population growth, high-density urbanization, industrial expansion, resource exploitation, and new and expanding technological advances, and recognizing further the critical importance of restoring and maintaining environmental quality to the overall welfare and development of man, declares that it is the continuing policy of the federal government, in cooperation with state and local governments and other concerned public and private organizations, to use all practicable means and measures, including financial and technical assistance, in a manner calculated to foster and promote the general welfare, to create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Americans."

The President's National Goals Research Staff in the recent report *Toward Balanced Growth: Quantity with Quality,* commented: "On the basis of these two contrasting policy declarations, the recently evolved position of the Congress apparently is that our society wishes to continue to expand its productive capacity, but that a more concentrated effort must be made to apply our technological prowess in harmony with social and environmental quality goals: i.e., to pursue a policy of balanced growth."

The Need for an Ethic

There are those who would conclude from this analysis of laws that they are toothless rhetoric, defanged by a basic misunderstanding of the conflict between use and conservation and by conditional phrases, loopholes and value words. But what is the alternative for achieving the

Strategies based on rigid numerical standards and time tables of compliance have been repeatedly rejected over the years as arbitrary, unscientific, a denial of improving knowledge and techniques, and certain to cost society more than is gained.

agreed-upon goal of productive harmony?

Some environmental changes have been effected in the past by devious means, which we can hardly recommend for today's problems and climate. Vannevar Bush, in his recent book *Pieces of the Action*, ascribes the decline of the steam engine for automobiles and simple boats to arbitrary laws: "The gasoline engine developers got legislation enacted in various places which prohibited an open flame in a garage, and the steamer had a pilot flame that generally was kept alight." As for boats, "Laws were passed, all over the land, which provided that only a licensed engineer might operate a steam engine. . . . No doubt the laws were favored by the steam engineers as likely to provide jobs. What they did was to make the steam launch obsolete."

Another alternative is to write laws which legislate rigid numerical standards and time tables of compliance. Even the technology to be employed could be specified. This approach has been repeatedly rejected over the years as arbitrary, unscientific, a denial of improving knowledge and techniques, and certain to cost society more than is gained.

From time to time the frustrations of continued environmental degradation, increased population concentrations, and growing technological impacts renew the call for uncomplicated, hard-line legislative fiat.

In the 1970 amendments to the Clean Air Act, the Congress for the first time legislated numerical standards by which, for example, automobile exhaust emissions are to be reduced to 10 per cent of the 1970 value by 1975. With careful and intelligent administration, such a challenge may be what the auto industry needs. On the other hand, rigorous interpretation in the absence of technological feasibility may disrupt the industry or result in very expensive and complex equipment. The outcome will be of interest to the entire nation—and especially to the 14 per cent of the labor force associated in one way or another with the automobile.

Toward a Social Conscience

The realities of the world situation support the legislative language of trade-offs, negotiations, progressively tightened requirements, and equity. An adequate, tenable standard of living for a controlled world population seems just barely within the grasp of civilization. It will only be achieved by the most intelligent use of natural resources and the recycling processes of the environment. Ecological principles show that, for the long term, maximum productivity coincides with a healthy, esthetically pleasing environment. This is the condition which we must create. Knowledge in the environmental sciences is not yet sufficient to specify the optimum condition in detail, but the directions away from many present practics are clear.

For the United States, social pressures and economic demands make it necessary to get "from here to there" without severe disruptions such as unemployment, materials and energy shortages, or regional depressions. The rational, sequential, science-based approach, allowing for variations of social and economic practicability as in the present laws, seems to be the preferred system. Fortunately, U.S. science is strong and should be fully focused on these environmental paradoxes. Ingenuity may quite often minimize the economic cost of improved air or water quality. New processes may well be based on the concept of essentially total recycle to minimize wastes. Land-use planning and systematic materials and fuels allocation can improve industrial efficiency and preserve environmental amenities.

The deep public concern creates receptivity to ecological information and will make possible an ethic which will sustain broad support when the costs of changed life style and reimbursement for past degradation are paid. In a democracy this ethic of environmental quality is the only ultimate basis for progress.

Rene Dubos reminds us that man can adapt to an environment of very low quality and still exist as a species. The question then becomes one of leadership and knowledge. By which route will society choose an ennobling state for itself and the living landscape?

M.I.T. CHAIR

Famed for quality craftsmanship, selected northern hardwoods, with gold M.I.T. shield, gold decoration on handsome black finish, the M.I.T. chair has earned the right to be a tradition. Choose black arms, $46, or cherry arms, $46. Red and grey Duraleather covered cushion, $11.

DIRECTOR'S CHAIR

Features the 3-color M.I.T. crest on the heavy white duck and black or natural varnish finish on the sturdy, foldable frame, $18.95

INSIGNIA GLASSES

The white Tech crest is fired on handblown quality glassware with platinum rim. Order Hi-Ball, $1.25 each, $14.00 per dozen or Double Old Fashioned, $1.30 each, $15 per dozen.

A good way to remember

PERSONALIZED PLAQUES

Cast bronze M.I.T. emblem is mounted on solid hand-rubbed walnut, shaped as a shield or rectangle (both 8½" x 11"). Graduate's name is engraved on the brushed sheet bronze nameplate. Engraving is filled with black inlay so letters appear in distinctive double outline style. Excellent gift idea. Order from Tech Coop. $18.95.

SCHOOL TIES

The M.I.T. shield is woven in a repeated pattern on plain backgrounds of red, black or navy. Fine quality silk repp, $6.

the Coop

M.I.T. Student Center
84 Massachusetts Avenue
Cambridge, Mass. 02139

PLEASE SEND:

☐M.I.T. Chair with black arms	Express collect	$46	-------
☐M.I.T. Chair with cherry arms	Express collect	$46	-------
☐M.I.T. Cushion		$11.	-------
☐M.I.T. Director's Chair, Natural	Express collect	$18.95	-------
☐M.I.T. Director's Chair, Black	Express collect	$18.95	-------
			Totals
☐Hi-Ball Glasses	@$1.25 ea., @$14.00 dz.		-------
☐Double Old Fashioned Glass	@$1.30 ea., @$15.00 dz.		-------
☐Red ☐Black ☐Navy Tie(s)	@$6. ea.		-------
☐M.I.T. Plaque with nameplate	$18.95		-------

Graduate's Name _____

Class of _____

Please ship to: _____

Address _____

_____ Zip _____

Ordered by: _____

Address _____

_____ Zip _____

Coop # _____

Charge my account ☐ _____

Check ☐ _____

Handling and shipping charges extra. Approx. 30 days delivery from Gardner, Mass. All chairs delivered in Mass. must be prepaid. Make checks payable to the Harvard Cooperative Society. Massachusetts residents: Please add 3% Mass. sales tax. (Out of state residents: No tax except when delivered in Mass.) Prices subject to change without notice.

TR-71

Trend of Affairs

Trends This Month

COMPUTING

Japanese self-sufficiency—and equal space . . . A TROLL to calculate social economics . . . A warning against a patched-together world-view.

TRANSPORT

Lead-free gasoline—the reasons and the consequences . . . A steam-car and a vapor competitor compared . . . Busses that come to your front door . . . Trains that go faster on the same old rails.

ECONOMICS

Japan finds the G.N.P. too gross a measure of success . . . And the Netherlands works out a better one.

EDUCATION

Among the new graduates, the engineers lead in a difficult struggle . . . Between President and President . . . Teaching and marking papers—a conflict of interest.

COMPUTING

Japan's Insular Computer Industry

Is there any hope that Japan represents an export market for American-made computing equipment? Not much, according to Franklin F. Kuo, of the University of Hawaii, whose survey of the Japanese computer industry was published this year by the U.S. Department of Commerce. On the other hand, neither will there be much traffic the other way, Professor Kuo thought (and this was before measures were taken to reduce imports into the U.S.).

Japan resembles the U.K. in that its computer market is by no means dominated by I.B.M. There is an I.B.M.-Japan, which likes to be regarded as Japanese and has about 30 per cent of the market; Oki-Univac has about 13 per cent. Half the nation's computer business goes to purely Japanese companies, and most of that is divided between "the big six"—Nippon Electric Company, Fujitsu, Hitachi, Toshiba, Oki-Denki and Mitsubishi Electric.

The big six cooperate economically with each other and with the Ministry of International Trade and Industry (MITI), while preserving an active rivalry on the technical side. Since 1961 they have shared a common leasing company, Japan Electronic Computer Company; any rented big six computer must first be sold to J.E.C.C. The renting company, writes Professor Kuo, is not just a business operation: it represents "a spirit of solidarity which links together *all* Japanese computer companies into an invisible union against outside encroachments."

In 1966, MITI set out to fund the development of a large, high-power machine, such as none of the nation's computer companies would have found it easy to launch single-handed. Nippon Electric (N.E.C.), Fujitsu and Hitachi have been joint primary contractors, farming out work to other computer companies, government laboratories, and universities. Target date for delivery is early this year. Professor Kuo describes the machine—a multiprocessor system with a mean instruction-execution time of 200 nsec—as "in the same class as a CDC 6600." It is questionable, he says, whether it will ever be sold commercially, but it will be—rather as was the development of IBM's STRETCH system—a focus for technological advances which will be used in later production machines.

N.E.C., Fujitsu, and Hitachi, which also share the country's biggest software company, are teamed up in another major program—the development of a time-sharing system for Nippon Telephone and Telegraph (N.T.T.). "In general," writes Professor Kuo, "time-sharing systems seem to be available in Japan, but not very popular," and N.T.T. "seems to be the only major firm that is planning to offer time-sharing on a large-scale basis." The N.T.T. system, which should be operational this year, will apparently be able to serve 600 active users simultaneously. Each of the three companies will independently produce a trial system, and N.T.T. will choose between them.

What are Japan's weak spots? Software is "quite underdeveloped" in comparison with hardware. Minicomputers made in the U.S. should be saleable in Japan, since "each company had only one minicomputer in production with the approximate capability of a PDP-8." Peripherals: demand seems to be ahead of supply, particularly for auxiliary storage devices, and Japanese terminals are "relatively crude" compared with American equipment—there is a notable dearth of C.R.T. terminals. But with those exceptions, the big six take care of themselves, needing little trade with other countries in either direction.

Finally, a historical note: Professor Kuo recalls that "in an effort to counteract the increasing trade deficit, the U.S. Department of Commerce and the Association for Computing Machinery (A.C.M.) held a computer ex-

hibition and symposium in Tokyo on October 12-17, 1970, called COMPUTER 70. The exhibition was based upon the premise that the United States is more advanced than Japan in computer technology. . . . The U.S. Ambassador to Japan, Armin H. Meyer, formally opened the Exhibition with a short address in which he hit hard at the trade deficit between the U.S. and Japan, and hoped that Japan would buy lots of U.S. computers to compensate for their excesses in other fields."

On October 3-5, 1972, Tokyo will host "the first major computer conference jointly sponsored by national professional organizations from the U.S.A. and Japan." In the words of the President of the American Federation of Information Processing Societies, Inc., (which includes A.C.M.) "the U.S.A.-Japan Computer Conference will enable computer experts from two of the world leaders in the manufacture and development of computers to assess and compare the technological developments from both nations." And the U.S. co-chairman of the conference promises "equal space to exhibits of U.S. and Japanese equipment and services. Similarly, there will be an approximate 50-50 split at the technical sessions. Stress will be on subjects of common interest and common concern."

Social Economics Quantified

A new model-building tool for economists and management scientists, attempting to make quantitative a large body of social science research for which theory has outstripped practice, is now going into service—the TROLL econometric research system, developed in the M.I.T. Department of Economics during the past four years.

TROLL was devised for use in developing large models of economic systems, to show how data on economic behavior relate quantitatively to each other. For example, the system can give numerical answers to such questions as: What will be the effect of an increase of 0.5 per cent in short- and long-term interest rates upon wages, prices, unemployment, investment, consumption, and gross national product? Or what would be the effect of a given change in corporate excess-profits tax?

In the hands of the Computer Research Center for Economics and Management Science (C.R.C.), TROLL will become COS, the "Center Operating System," available to economists, managers, and even scientists throughout the U.S. through a time-shared, interactive system.

The new Computer Research Center is a project of the National Bureau of Economic Research, Inc. (N.B.E.R.), a 50-year-old nonprofit corporation based in New York; C.R.C. is financed by a two-year, $1.9 million grant to N.B.E.R. by the National Science Foundation with a commitment "in principle" for an additional $3 million of funding for three years thereafter. C.R.C.'s Executive Director is Edwin Kuh, who is on leave for the current year from his duties as Professor of Economics at M.I.T. Mark Eisner, who studied economics with Professor Kuh at M.I.T., is Technical Director, and C.R.C. is governed by a Policy Committee representing seven leading universities headed by John R. Meyer, Professor of Economics at Yale.

Having TROLL "in our closet," says Dr. Eisner, is C.R.C.'s biggest current asset. The Center's first task will be to extend the benefits of TROLL to researchers throughout the U.S. by time-sharing C.R.C.'s own computer or by putting needed parts of the TROLL program into others' machines. This accomplished, the C.R.C. will proceed with studies of other techniques for economic analysis, "programming those which offer the greatest promise of stimulating new types of empirical research," says Dr. Kuh.

"Since we are essentially working on new research tools, the possible benefits are not limited to economics and management science," Dr. Kuh said. The new software tools will be applicable in any discipline dealing with "complex masses of data characterized by interdependencies, nonlinearities, and other complications which are evident in the way real-world systems change over time". The real-world systems may be anything from the economy of a developing nation to a string of protein molecules.

"Science" as the Opium of the People

"There are two distinct meanings to the word *science*. The first meaning is what physicists and mathematicians do. The second meaning is: a magical art, about which the general public has superstitions."

The speaker was Jerome Y. Lettvin, Professor of Communications Physiology at M.I.T., and he was addressing a recent conference on "Culture and Science" held by UNESCO in Paris. Professor Lettvin has long been known for his habit of reminding the logic-bound that there are more things in heaven and earth than will conform to rigorous analysis. But in Paris he seemed seriously afraid that the battle between the spirit and the letter (more precisely, of course, the alphanumeric character) may finally be lost.

It is becoming common to speak of a rise of neo-Luddism; but Professor Lettvin still finds that in the minds of the majority of people, " 'Science says' has replaced 'scripture tells us,' with no more critical reflection on the one than on the other."

This science-based public faith contains dangerous errors, accepted without criticism even by those who pass as rebels (which may be why Professor Lettvin does not mention the "neo-Luddites"—at bottom, they are conventional in their axioms): "The most vicious thing that this public science says—the supporting lie on which revolutionary and reactionary alike agree —is that truth is in number, numbers are in machines, machines are not human, and are therefore just."

The computer has also had a distorting effect on the minds of the scientists themselves. In former times "one used to assume that laws are simple but hard to find." But the computer can extract results from an inelegant concatenation of data and equations without anyone having really understood anything. "It is possible, for example, to patch together weather prediction, or the location of oil deposits, or putting a man on the moon, because the dogwork of patching data can be done easily and rapidly by machine. . . . However, the patchwork is not usually a theory in any classical sense."

The result is that the effort to acquire real insight into nature is neglected, as unnecessary. "The phenomenal world fades. What one perceives becomes not different in substance from the confections that model it, and the models not different in principle one from the other." Today, says Professor Lettvin, even the young see the world not as "a great chain of being" but as "a jigsaw puzzle, the connections between the parts arbitrary or conventional, the nature of the parts accidental or contrived."

The detachment from sensible reality —which Professor Lettvin calls Antaeism, "after the unhappy giant that Hercules killed by keeping him from touching the earth"—extends to notions of human nature itself.

"From the nature of psychological tests, from the results of brain stimulation, from the discovery of 'centers' in the brain (e.g. those for 'pain' or 'pleasure'), from the attempt to make the blind see by inserting a primitive television set into the brain . . . from the whole of contemporary psychology and so-called brain sciences, the image of man is that of a determined mosaic of stimulus-response mechanisms, perhaps modified contingently, but still a clock-work that can be disassembled."

And if individuals can be viewed this way, so can groups: there is now a

kind of social scientist who "writes the thermodynamics of the masses, defines social heat, social order, social equilibrium, etc." He is not, says Professor Lettvin, the real scientist that he claims to be, for he has detached himself from reality. But he is "heard in the parishes to which high learning never penetrates, and it is from him that the new church emanates."

And in this new church, a new saviour is about to be born: Artificial Intelligence. "You have heard vague rumors of his coming, but there will be a point at which you will be told that he came but you were looking elsewhere.

"Again, as always, there are two aspects to the science. On the one hand there is the serious attempt, first, to find what are the properties and limits of computers . . . and second, whether human perceptions and judgement have rules that can be formalized . . . On the other hand there is the public aspect, that promises new hope for automatic babysitters, psychiatrists and executives. . . . From the government's point of view, I may add, it doesn't matter one bit whether the device can be used, for all that is required of it is proclaimed existence, the public belief in an inspired golem, for the government to let it be known it is in use. Wiener attributed too much integrity to our leaders in his warning on this subject. . . ."

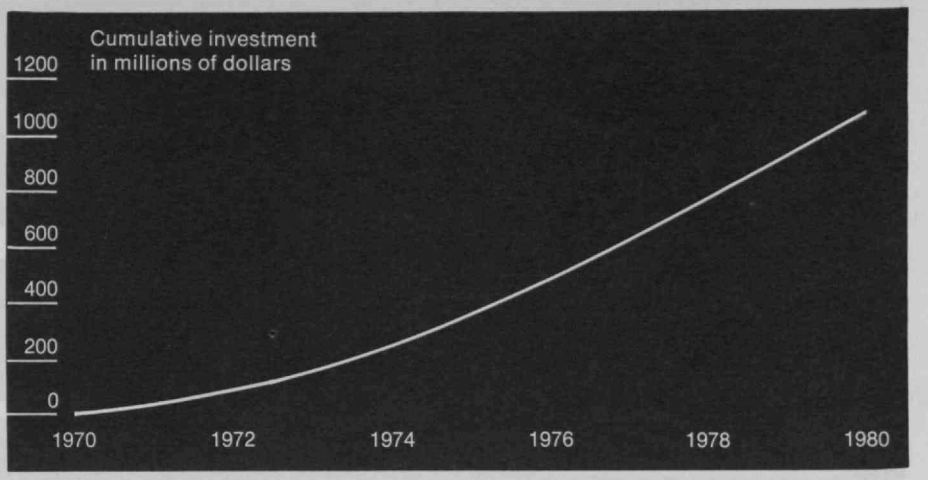
TRANSPORT

Gasoline Lead: Goals and Penalties

In the Sept. 7, 1971 issue of *New Scientist and Science Journal,* Jon Tinker quotes a report said to be written by Mobil Oil Company's Management Sciences Department: ". . . lead should be removed from gasoline because it contributes to engine deposits, causes particulate emissions, increases hydrocarbon emissions, is a dangerous heavy metal poison and destroys the effectiveness of catalytic converters. These reasons for removal justify an immediate effort to reduce the average lead content of gasoline."

Tinker comments: "What is significant is that Mobil . . . is being urged to accept the anti-lead case as a political if not a scientific fact, and to concentrate on how best to phase out lead." And as to that question, he notes, "Mobil argues that the only effective way to cut down on lead is to reduce the octane rating used by the motorist."

It is not just a matter of health. In *Airborne Lead in Perspective* the National Research Council concluded that airborne lead does not provide a serious health hazard for average adult city dwellers, although children —and adults working close to engine exhausts—could get enough lead in their blood to cause damage. The report emphasized that the average lead content in the air over major American cities (although 2,000 times that over the central Pacific) hasn't changed greatly in 15 years, and that in any case most of the lead in the blood comes from food and drink.



An example of the investment that might be required to satisfy the increased requirements for gasoline resulting from lower mileage-per-gallon due to reducing lead and/or octane levels. In this particular case, it is assumed that cars built during the decade are designed for 91 research-octane-number fuel, and suffer a 5 per cent fuel-economy penalty; and that cars built after 1973 suffer a further 5 per cent penalty due to the addition of emission control devices. This is one of a number of cases analyzed in the economics appendix to *The Implications of Lead Removal From Automotive Fuel* (Department of Commerce, 71-00568.)

According to Lead Industry Association estimates, 278,500 short tons of lead went into gasoline anti-knock additives in 1970—about 20 per cent of total lead consumption. What becomes of it? Could it possibly settle out of the air, build up in the soil and then show up in food and drink? Dr. Tsaihwa J. Chow of the Scripps Institution of Oceanography has found using radioisotope tracers that gasoline appears to be the origin of the greatest proportion of airborne lead. In this connection Tinker points out in another article that "lead in piping, toys, paint, and pottery has been steadily restricted in recent decades while lead in petrol has doubled in one decade."

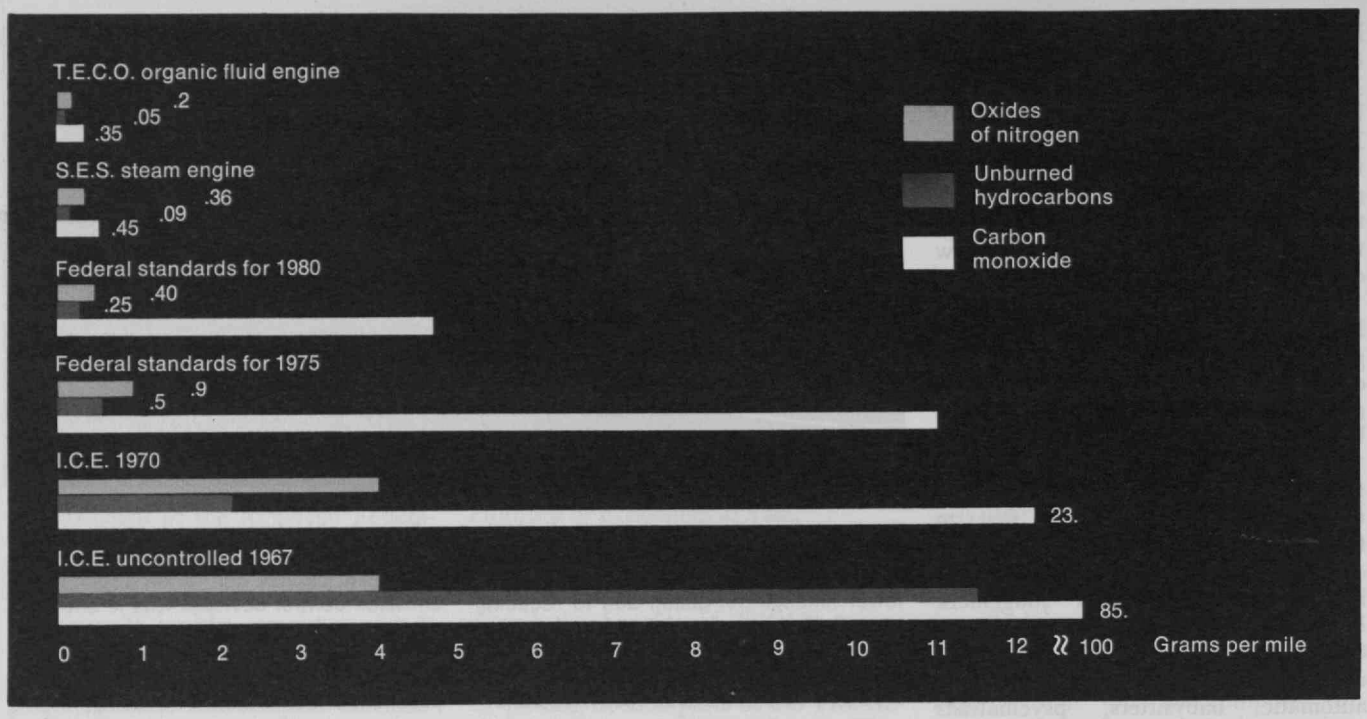
But it is not agreed that airborne lead eventually finds its way into the human body. An interim survey by the United States Public Health Service showed almost no correlation between airborne lead and lead in human blood.

What about lead's contribution to overall automobile-caused air pollution? If all of the lead in gasoline appears in the exhaust, then average particulate emission rates must be about 0.2 grams of lead per mile, or about six times the proposed 1975 standards for particles. But removing the lead may affect gaseous emissions. When refineries do not add lead they must—if the octane rating is to be maintained—add aromatic hydrocarbons. And some evidence suggests that octane-boosting aromatics increase pollution.

The Bartlesville Petroleum Research Center of the U.S. Bureau of Mines found that exhausts from two unleaded fuels showed a significantly higher rate of smog-like chemical reactions than did the exhausts from two leaded fuels. This data corroborated research findings of the Ethyl Corp. (admittedly a major supplier of tetraethyl lead to refineries), relating to the concentrations of aromatic aldehydes in the exhausts of engines burning leaded and unleaded premium fuels. Aromatic aldehydes belong to a group of chemicals that are strong eye and skin irritants and that may react photochemically to produce smog. The Ethyl Corp. report states that "the concentration of aromatic aldehydes and phenols in automotive exhaust gas increase with the aromatic content of the fuel."

But earlier tests under slightly different conditions by the Bureau of Mines failed to prove one way or the other the higher smog potential of unleaded gasolines. And as recently as March 1971 a panel on Automotive Fuels and Air Pollution reached the conclusion that there are no satisfactory data available to prove that increased aromatic content causes more smog.

On the other hand, leaded gasoline fouls catalytic reactors—the only devices on the horizon for reducing gaseous pollutant emissions to the legislated 1975 standards. This alone demands that lead be phased out before 1975. The Department of Commerce Panel on Automotive Fuels and Air Pollution examined some strategies



Exhaust-gas emissions: (bottom to top) from internal combustion engines before present equipment to control them was installed; from engines that would meet the 1975 and 1980 standards; and from the Rankine-cycle external-combustion engines being built by the Steam Engine Systems Corporation and the Thermo Electron Corporation.

to reach this goal. Among their findings and recommendations:

☐ Regulations should require the nation-wide availability of a low-lead fuel by the end of 1972 and an unleaded 91-octane fuel by July 1, 1974. Price incentives should be considered, to guarantee that the unleaded fuel is cheaper to the consumer.

☐ The production cost of unleaded, 91-octane fuel is unlikely to be more than 1¢/gallon above that of leaded 94-octane regular.

☐ However, on a per-mile basis, decreases in fuel economy caused by low compression ratios and emission control devices will raise costs to consumers, increase crude oil consumption and necessitate much additional refinery construction. This extra refining plant is within the construction capacity of the industry—provided that de-leading is phased over a five-year period.

So de-leading is, in a way, rather good business.—*Michael Chiusano*

From Stanley to Doble to. . .

A man named Doble built some steam cars back in the 1930's, and most of them are still running. They're collected around San Francisco, and probably tended with more concern than most cars, but Jack Vernon, President of Steam Engine Systems Corporation (S.E.S.) cites them as proof that steam is workable and may power a more durable engine than the internal combustion (I.C.) engine.

Steam, or some other vapor, is used in a type of external-combustion engine called a Rankine-cycle engine. Fuel is burned continuously in a boiler to evaporate a working fluid. The vapor drives a set of pistons, and returns via a condenser as liquid. The Environmental Protection Agency (E.P.A.) and D.O.T. are both supporting research in Rankine-cycle engines, the E.P.A. for cars and D.O.T. for busses. The E.P.A. contract for a Rankine engine using water as the working fluid—i.e., a steam engine—was given to S.E.S.

Mr. Vernon emphasizes that there are no great breakthroughs in Rankine-engine technology; rather, those who are now building steam engines are using some better materials and some new information—for example, about heat transfer—collected over the past 10 to 15 years. The Rankine engine is now small enough to fit into the same space as an I.C. engine, thanks to the development of small boilers and small condensers. His company is patenting a boiler 15 inches high and about 20 inches in diameter; S.E.S.'s innovations concern the shape of the flames in the burner and the configuration of the tubing that carries the water to be heated. The associated condenser is about 50 by 20 by three and one-half inches—small enough to fit across the front of the Rambler Ambassador into which it will first be put. The cylinder head is (with a few modifications) an aluminum diesel V-4 already being produced.

The S.E.S. drive train will be nonstandard, because a steam engine can be driven without gears, but it will have a transmission with two forward gears and one reverse. Otherwise, Mr. Vernon said, the driver will notice little difference when he tries a Rankine-cycle car. S.E.S. expects its car to do 19 miles to the gallon at 50 m.p.h., and to generate 130 b.h.p. at 2000 r.p.m. and 1000 p.s.i. cylinder pressure. It will take 30 to 45 seconds to start up, and then accelerate from 0 to 60 m.p.h. in 12.4 seconds.

Thermo Electron Corporation (T.E.C.O.) has received E.P.A.'s contract for a Rankine engine using an organic fluid (trifluoroethanol). According to Thomas Widmer, Director of Research, steam will corrode a carbon-steel and cast-iron engine, and is incompatible with petroleum lubricants, whereas an organic fluid has neither fault. (Mr. Vernon replies that S.E.S. has developed a lubricant with which he does not expect difficulties, and denies that steam will corrode the S.E.S. stainless-steel boiler and tubing, provided that distilled water is used.)

Organic fluids, unlike water, impose temperature limits, beyond which they decompose (into gases dangerous to life, Mr. Vernon said, but a T.E.C.O. representative denied that possibility at the I.E.E.E.'s fall Northeast Electronics Research and Engineering Meeting). T.E.C.O. has designed a boiler using a double-walled tube, with water in the outer tube to shield the trifluoroethanol from hot-spots. A gauge shuts the flame off if the fluid begins to overheat. The

system containing the fluid is hermetically sealed, so maintenance will be slight. Mr. Widmer expects the engine to be therefore more durable than an I.C.E. The vapor leaves the boiler at 500° F and 700 p.s.i., and is compressed further before it enters the cylinder. (Mr. Vernon counts the higher temperatures possible with water as an advantage on grounds of thermodynamic efficiency.)

T.E.C.O.'s car, too, it is claimed, will feel little different from an I.C. car from the driver's standpoint. As regards power and acceleration, T.E.C.O.'s goals are similar to those of S.E.S.'s. A definite advantage of an organic fluid is that it will not freeze in winter, but S.E.S. will provide a mechanism to keep its water warm, such as a well with a pilot light.

The real advantage of Rankine engines, of course, is their low rate of emissions, as the chart shows. When fuel is burned to explode against a fast-moving piston in an internal combustion engine, the quickly changing temperature and pressure cause incomplete combustion. But when combustion is separated from the transmission of power, it can be—and in these engines is—complete. Emissions are considerably less than federal laws require.

The size of a vapor engine is no longer the conclusive drawback it once was. So the remaining question is one of safety: what happens in an accident if the boiler ruptures, or if the tank breaks open and its fuel is lighted by the boiler's open flame? Both T.E.C.O. and S.E.S. will install a boiler shut-off mechanism; both say that only a few quarts of hot liquid are involved, and will cool quickly in the open air.

Both companies have schedules that call for operating standard cars with their engines by the mid-70's; mass production should be possible a few years later.

Door-to-Door Bus

Busses look to many—including the Urban Mass Transportation Administration (U.M.T.A.)—like the best way to get people moved around in cities for the next decade, although certainly they can be used more imaginatively than in the past. One way is called demand-responsive service, meaning that the bus, a small one, appears where and when you call for it, like a shared taxi. A conference at M.I.T. last summer described the "Dial-a-Ride" (D.A.R.) systems now in use and planned.

The most successful one in use is part of Toronto's transit system; it travels between homes in the suburb of Bay Ridges and a high-speed rail link into the city. Bay Ridges is a typical suburb of 15,000 without other public transit. The system is small, employing only four eleven-passenger busses during rush hours and one or two in off-hours. The fare is 25¢, about half of what the ride costs. The transit authority makes up the difference. The yearly budget is about $76,000. Most commuters now subscribe to the service by the week (for a 20¢ fare), and half of the 1,100 who ride the train take the bus to and from it. William Howard, of the Government of Ontario transit office, feels the line is successful, and Ontario plans to continue it indefinitely.

U.M.T.A. will run a parallel system in the United States in Haddonfield, New Jersey. Ten busses will deliver riders to the Lindenwold Line, a privately built and very successful high-speed railroad into Philadelphia. An investment of close to $2 million by U.M.T.A. will demonstrate D.A.R.'s usefulness in serving a suburban area of 14,000 to 25,000 people for one year. Eight hundred and fifty passengers ride the Lindenwold from Haddonfield each day; 283 of them walk, 30 ride bicycles, and the rest seem fair game for the 75¢ Dial-a-Ride.

Service will be more extensive than Bay Ridges': 24 hours a day, and to places in the town other than the train station and the shopping center. In any Dial-a-Ride system, each vehicle's route is individually planned, since it must take in a specific group of passenger-origins (if not of destinations). One reason the cost of the New Jersey system is greater is that the routes, although manually worked out at first, will by the end of the demonstration be devised by computer. The computer is one answer to a question put to Marcel Zobrak, from MITRE (which manages the project for U.M.T.A.), at the conference: Aren't you reinventing the wheel (since the Ontario system works)? The $2 million will also pay for a number of surveys and evaluations.

The initial work on computer programs for D.A.R. service was done at M.I.T.'s Urban Systems Lab, and the lab was invited by the city of Rochester, N.Y., to help it plan a D.A.R. computerized system. The project has the support of local industry and the New York D.O.T.—even U.M.T.A. asked to be included. But then it was decided to fund Rochester only after the data is in from Haddonfield. U.M.T.A. is scheduled to provide $600,000; another $313,000 will come from local and state sources.

The Rochester service also is planned to run only for one year, as a demonstration, although it is supposed to be financially self-supporting by then and ready to continue on its own. It will be an intra-city service in part of Rochester and a suburb known as Greece. Greece contains 100,000 people, in 25 square miles, 11,400 of whom work at the Kodak plant. Greece also has shopping and recreational centers. Ed Porter, of the Urban Systems Lab, explained that rides will cost $1.00 (75¢ by subscription), and at the end of the year 20 busses will carry 3,000 riders a day. By then, revenues and costs will meet, at $57,000 a month.

And Lafayette, Indiana, will have D.A.R. service without Federal funds and with a computer. As Kenneth Heathington, a professor of civil engineering at Purdue, explained, it will be the town's only public transportation: it will not be a demonstration. When the town's bus company folded, a study examined 14 different combinations of service—both fixed-route and demand-responsive. A partly demand-responsive system seemed best. Seven to ten busses will serve the 20 square mile area. Some subsidy will probably be needed. Midwestern as it is, said Dr. Heathington, Lafayette came around to the idea that public transportation was a service, like parks and schools, that ought to be helped with public funds. Since the conference, six or seven other demand responsive systems have started up.

British Trains For Amtrak?

The British Advanced Passenger Train, according to British Railways' Director of Research Marketing, could revitalize U.S. rail passenger service: scheduled to start regular service in England in 1974, the A.P.T. will travel safely and comfortably at speeds up to 155 m.p.h. without requiring any improvement to the roadbeds, Mr. Paul Cautley told an audience at the New England Research and Engineering Meeting in Boston this fall.

Running expenses are expected to be no higher than those of today's conventional trains. And speedy and economical service over track intended for 60-m.p.h. trains was only one of Mr. Cautley's many selling points.

Like the United States today, Cautley recalled, Britain once witnessed the decline of profitability and passenger acceptance of her rail network. But soon after the crown granted, in 1947, the charter which established British Railways as a government-owned corporation, improvement became possible. Cautley cited traffic increases of 5 per cent per year on inter-city (London to Glasgow, for example) trains; earnings on these runs have gone up 10 per cent per year in recent years. In short, British Rail capitalized on the fact that in Britain, distances

too short for planes and too long for cars can best be served by high-speed rail service.

And Cautley believes rail can best serve these distances in the U.S. as well. He emphasized that in planning the upgraded inter-city rail network, B.R. was most concerned with "new cost-effective techniques, not an instant solution for quick profits."

Cautley pointed out that Japan's 150 m.p.h. Tokaido Express between Osaka and Tokyo required track so straight that per mile costs exceeded $2 million.

Thus, rather than attempting a program that would have straightened and re-aligned existing railbeds to the standards required for 150 m.p.h. speeds with conventional (albeit powerful) trains, B.R. concluded that a radically improved vehicle running on conventional track would give lower costs.

Typically, one A.P.T. consists of two electric- or turbine-powered cars of 2000 h.p. each with eight trailer cars, for a full-up weight of 250 tons—about one-half the weight per passenger seat of a conventional train. A sophisticated wheel suspension and a servo-system to actively tilt the cars permit 55 per cent higher speeds around curves (*see also* Technology Review *for April, 1970, p. 69*). Hydro-kinetic braking (dissipating energy by forcing fluid through a small nozzle) is used for high-speed (150-100 m.p.h.) deceleration, after which conventional brakes take over.

The idea of using British equipment on unimproved U.S. track—to boost Washington to Boston speeds, for example, to around a 100 m.p.h. average—is being taken fairly seriously. Importing British-made rolling stock would be over-costly, of course, but it is conceivable that a major U.S. manufacturer could obtain a license from British Rail.—*Michael Chiusano*

ECONOMICS

Beyond G.N.P.: In Japan. . .

"The Japanese Government has been sponsoring thoughtful research into improved economic indicators that would give us a better understanding than the traditional G.N.P. of the *qualitative* aspects of economic growth. We call the new concept 'net national welfare', or N.N.W." Thus said Mr. Hiroshi Uchida, Japan's New York Consul General, during the 8th Annual Meeting of the American Institute of Aeronautics and Astronautics in Washington.

"N.N.W. will exclude," Mr. Uchida said, "those expenditures which do *not* improve the quality of life—including antipollution expenditures which simply maintain existing quality and, of course, military expenditures. It will include, however, those expenditures which contribute to improved life quality—including the restoration of the environment to earlier quality standards."

Japan has recently undergone an about-face in its attitude towards pollution, from serious neglect to serious attention. Mr. Uchida admitted that his country might well have "ten times the pollution problem of the United States"—but this situation is now being squarely faced. "During the next decade," said the Consul, "it is anticipated that 8 per cent of all new equipment investment in Japan will be for antipollution devices," which would probably be the highest such ratio anywhere. Already, between 1966 and 1970, "the ratio of antipollution investment to total private investment has doubled, to nearly six per cent." Mr. Ushida acknowledged that "sheer quantitative production is no longer a sufficient index to human 'progress'." And he quoted Japan's Ambassador Ushida:

"Once we were a garden. But in our haste to catch up with the modernised West, we have cluttered our cities, scarred our countryside . . . . We have dreams of becoming a garden again."

. . . and the Netherlands

Work rather similar in its objectives to the Japanese "net national welfare" studies is in hand at the Netherlands Central Bureau of Statistics. But there is one important difference: in the Dutch version, nothing is deliberately left out of the reckoning as being a "non-good"—on the contrary, the improved G.N.P. calculation would include everything that is counted at present, plus a new category of variables, the goods or services provided by nature—which are variable in that they tend to diminish.

As presently defined, G.N.P. is the total dollar value of the goods and services generated by a given society within a given year. It is well known that certain types of undoubtedly useful activity are hard to reckon; but economists have ensured that, within its stated objectives, the present G.N.P. calculation is the best that can be managed. Besides, what is usually of interest is the G.N.P.'s rate of change, a figure in which confidence can be placed even if the absolute magnitude is debatable.

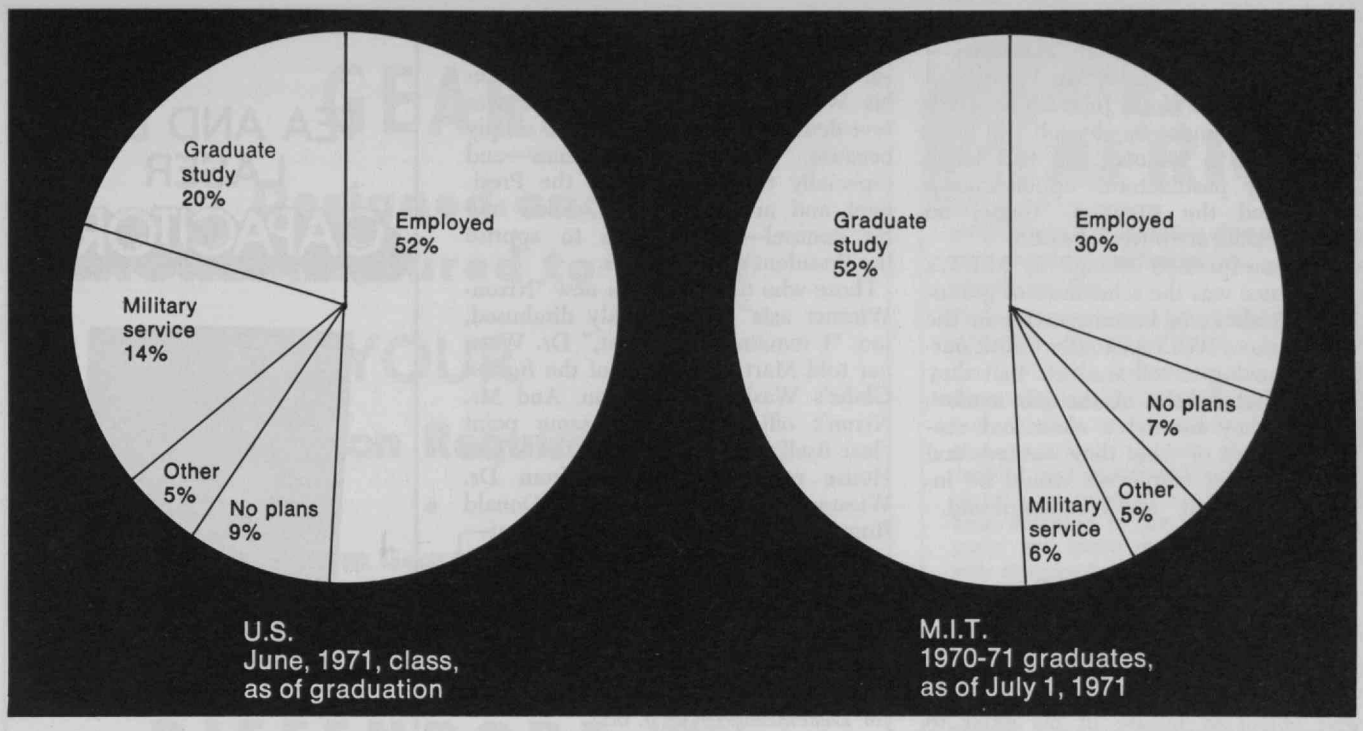
But Dr. R. Hueting, of the Department for Health Statistics of the abovementioned Hague bureau, finds one basic shortcoming in all this: the G.N.P. calculation measures the goods produced by man (which tend to increase—hence the annual rise of a few percent), but it makes no mention of the goods provided by nature, which range from breathable air and swimmable water to insects which pollinate commercial crops. Unless deliberately conserved, these natural goods tend in industrial conditions to diminish. This diminution, when discovered, gives rise to a deeply felt sense of loss, but no clear notion of what to do about it.

But Dr. Hueting sees no need for emotional outcries, or for unquantifiable appeals to aesthetic sensibilities or ethical principles. Nature, he says, provides material goods, to which economic values can be assigned according to taste, just as they are assigned to the works of man (however subtle and profound). If there is any difference between nature's products and man's, it is that the former tend to be provided to people in general and the latter to individual buyers—but there is nothing new about national governments making purchases on behalf of their whole electorates.

Dr. Hueting's team has set about creating the same kind of numerical values for natural goods as are available for man-made products and services. The two can then be pulled together into a single system of accounting. Thereafter, decisions regarding industrial development would play off the gains in man-made goods against any consequent natural losses.

Addressing a small but international conference recently organized by Harvard's Professor John W. Pratt on statistical aspects of pollution problems, Dr. Hueting sketched out the procedure his group uses to assign economic values to environmental alterations. In practice, the project involves a great deal of detailed work—the "gross natural product," as it might be called, is of a similar order of complexity to the G.N.P. that we know. One by one, the uses of natural resources must be economically evaluated (some values may be infinite); conflicts between uses must be identified—in the form either of competition for a quantitatively limited resource, or of the loss of one use as a side-effect of another; and hence the true cost of each activity, or of restoring the possibility of that activity after it has been lost, can be worked out.

It was remarked that although this Netherlands approach to environmental problems was not without its difficulties, it was at any rate a feasible, rational strategy, in a field characterized by arbitrary decisions, bootless mutual recrimination, and a widespread suspicion that the values at stake are not commensurable.



Though 9 per cent of U.S. engineering graduates were without job offers or other firm plans by the time of graduation, John D. Alden, Director of Manpower Activities for Engineers Joint Council, says his organization's 1971 national survey (left) shows that engineering students "did extremely well in terms of finding employment" in 1970-71. By July 1—at least a month later than most of Mr. Alden's data were taken—only 7 per cent of M.I.T.'s 1970-71 engineering graduates (right) remained without future plans, according to Robert K. Weatherall, Director of Placement. But in 1969-70 57 per cent continued for advanced degrees—compared with 52 per cent of those whose plans were known to M.I.T. in 1970-71. "Press reports of the impending decline of the engineering profession," Mr. Alden writes, "must be regarded as highly exaggerated."

EDUCATION

New Engineers in the Job Market: OK

The image of the unemployed engineer notwithstanding, John D. Alden, Director of Manpower Activities for Engineers Joint Council, thinks engineers in the Class of 1971 did at least as well in the job market as any of their colleagues in other fields.

M.I.T.'s data, within the range of fields in which the Institute awards degrees, agree: as of July 1, only 3 per cent of all the Institute's 1970-71 engineering graduates had yet made no plans for the current year. The figures were higher for students in science (6.5 per cent), management (6.5 per cent), the social sciences (8 per cent), and architecture and planning (10 per cent), according to Robert K. Weatherall, Director of Placement.

The 1971 edition of the annual college placement survey conducted by Mr. Alden's office shows that 9 per cent of engineers graduating last June from U.S. colleges and universities were without job offers or firm plans at the time they graduated; this is about double the figure for 1970. Of master's and doctor's degree recipients, 2 and 4 per cent, respectively, were still job-hunting at graduation time, compared with 11 per cent of the bachelor's.

Late in the fall, the American Chemical Society made its own "grim" report on the basis of a survey of chemistry and chemical engineering departments. Unemployment among new chemistry graduates was 10.3 per cent in 1971, up from 5.1 per cent in 1970. Among new chemical engineers, A.C.S. said, an "alarming" 12.8 per cent were unemployed in 1971. Starting salaries for chemists were down but were modestly improved for chemical engineers.

Mr. Weatherall uses the phrase "challenging" to describe 1970-71 in his annual report, because hiring of graduates "was down in virtually all sectors of the economy." Fewer firms—by 25 per cent—came to interview students at M.I.T. during the 1970-71 year, and they usually had fewer jobs to offer. He cites the case of a large petroleum company which normally hires 500 new technical staff at the bachelor's and master's degree levels; this year the company was looking for 80; instead of over 100 doctorates it needed four.

M.I.T.'s figures show that 7 per cent of the bachelor's, 1.5 per cent of the master's, and nearly 3 per cent of the doctorates in engineering remained without settled plans in July, 1971. In addition, Mr. Weatherall reports, a "disproportionate number" of June graduates with doctor's degrees took temporary research and fellowship appointments, and a number of students who were scheduled to receive degrees from M.I.T. during the year took action to postpone their graduation or register for longer programs.

Salaries nationwide for new engineering graduates in 1971 were slightly higher than in 1970—an increase of 1.7 per cent for bachelor's and 0.2 per cent for master's degree holders, according to Mr. Alden; but doctorate salaries were down almost 3 per cent (to $1,340 per month) from the 1970 levels, on the average. Chemical engineers commanded the highest salaries, civil engineers the lowest. Women did better than men, and women engineering graduates were "the aristocrats of their sex as far as salary offers were concerned," Mr. Alden said, in reporting E.J.C.'s survey results to the annual meeting of Engineers Council for Professional Development this fall.

Salaries of M.I.T. engineering graduates were up slightly from 1969-70: the salary median for bachelor's was $875, up from $870; that for master's was $1,050, up from $1,000.

Doctorates were the hardest hit among M.I.T. graduates. As of July, 17 of 247 leaving the Institute in June with Ph.D. or Sc.D. degrees were without jobs; in addition, a larger proportion than usual had taken postdoctoral appointments, and a larger-than-usual

proportion of the foreign students had elected to return home. In chemistry—perhaps the worst case, Mr. Weatherall said—only one of 21 June Ph.D. graduates had found a faculty job and none had a job in industry; 13 had taken temporary postdoctoral appointments. He called the situation "tragic; no wonder some are bitter," he said.

One unexplained change in M.I.T.'s experience was the reluctance of graduating students to become active in the job market. "We repeatedly found ourselves having to tell students that they should not be shy of the job market, that if they formed a clear and reasonable idea of what they wanted, and went after it, employers would be interested in them," Mr. Weatherall said.

Congratulations...

Early in November the White House unexpectedly called President Jerome B. Wiesner at M.I.T.: Would Dr. Wiesner object to release of his letter to President Nixon of October 4? Dr. Wiesner, surprised by the inquiry, quickly gave his consent as a matter of courtesy.

It was only one of several letters which he has written at intervals to Mr. Nixon; Dr. Wiesner has the notion, he says, that as a citizen who serves as a White House adviser it is proper for him to express his judgments of matters in which he knows the White House is concerned. He also felt that—because he had in the past been critical of some presidential policies—he should say so when he approved:

"Mr. President:

"I wish to congratulate you on your recent and dramatic actions regarding the economy and the nation's relations with China. With these steps you have opened up opportunities for creative movement where much less existed before. In both the economic sphere and in the search for rational international arrangements, your courageous steps will be landmarks.

"I have always believed that significant progress in political fields can only flow from major breaks with the status quo. If one tries to move forward slowly on any important problem, one small step at a time, all the persons and organizations with uncertainties, fears, or vested interests are certain to rally and frustrate the initiative.

"Strong, positive moves like these will do much to restore the nation's self-confidence and sense of dignity and morale.

"Congratulations.

"Sincerely yours,

"Jerome B. Wiesner,

"President

Dr. Wiesner rejects the labyrinthine speculations of self-interest in which some political observers engaged after his White House correspondence was revealed. His letters are written simply because, he says, all citizens—and especially those who know the President and are occasionally called into his counsel—have reason to apprise the President of their views.

Those who tried to find a new "Nixon-Wiesner axis" were quickly disabused, too. "I remain a Democrat," Dr. Wiesner told Martin F. Nolan of the *Boston Globe*'s Washington Bureau. And Mr. Nixon's office made the same point clear itself: on the same day the White House released the letter from Dr. Wiesner, it also—through Donald Rumsfeld, Assistant to the President—sent congratulations to Robert Machol, President of the Operations Research Society of America, for preparing a report critical of actions by A.B.M. opponents during the 1969 Congressional debate (*see* Technology Review *for December, 1970, p. 68*).

Teach vs. Certify

The trouble with university teaching as teaching—or at least one of the troubles—says Peter H. Elbow, Assistant Professor of Literature at M.I.T., is that most of it is not really teaching at all; it is certification, the process of making sure that something has been learned, rather than the process of learning it.

On the basis of experience in M.I.T.'s Experimental Study Group, where examinations, grades, and requirements are de-emphasized, Professor Elbow suggests that teaching and certifying should be completely separate so that both parties to teaching—the teacher and the student—can focus honestly on a partnership instead of an adversary role.

The present confusion of teaching and certifying lead to what Professor Elbow believes is "an important psychological impediment inherent in most teaching: too many teachers . . . actually come to develop feelings of wanting to protect their subject from their student." Why? The teacher is, of course, deeply devoted to his subject; he regards as precious the subject matter which represents wisdom he paid for dearly, says Professor Elbow. His natural desire "is to veil and protect what is precious" from perversion and false pressures. He thinks to himself, "I don't mind engaging in the mess called teaching as long as it's in other folks' fields, but there's going to be no playing and mucking around in *my* field. I speak about *my* field only to the already-committed, the already-worthy."

Puzzle Corner

Allan J. Gottlieb

Assume a Solution Exists

There has been some confusion between the author and the editors as to my deadline. Since I am late with this column, please forgive (but please do not applaud) my omitting the customary opening monologue. (But please note: send problems, solutions, and comments to me at the Department of Mathematics, University of California, Santa Cruz, Calif., 95060.)

Problems

The bridge problem for this month is by Allan Truscott of the *New York Times* by way of Frank Mouel, who wants to know:

51 Can the following contract be made against any defense?

	♠ 7 3 2 ♥ 5 4 2 ♦ A 10 9 7 6 ♣ 3 2	
♠ K 6 4 ♥ K J 7 6 ♦ K J ♣ K Q J 5		♠ 8 ♥ 9 8 ♦ 8 5 4 2 ♣ 10 9 8 7 6 4
	♠ A Q J 10 9 5 ♥ A Q 10 3 ♦ Q 3 ♣ A	

South	West	North	East
1 ♠	Double	2 ♦	Pass
3 ♠	Pass	4 ♠	5 ♣
5 ♠	Double	Pass	Pass
Pass			

A geometry problem from Frank Rubin:

52 A sphere is inscribed in a tetrahedron (not necessarily regular). From the four tangency points, lines are drawn to the three adjacent vertices. Prove that the three sets of angles thus formed are equal.

Mark Baldwin submits the following "Cartesian geometry" problem:

53 Given a circle [of radius r and center (h,k)] and a point P [having coordinates (p,q)], find, without using calculus, the coordinates of the point B on the circle having the property that the line segment PB is tangent to the circle.

A cutie from John T. Rule, who writes, "For my money, the following is one of the most intriguing of all problems; it comes from none other than that master puzzler, Sam Lloyd:"

54 All cows eat always at exactly the same rate. Four cows eat three acres of grass in two weeks; three cows eat three acres of grass in three weeks; How long will it take five cows to eat six acres?

The final problem is from P. Markstein:

55 Let F_n be the nth Fibonacci number ($F_0 = 0$, $F_1 = 1$, $F_i = F_{i-1} + F_{i-2}$). Prove that $F_{n-2^4} \equiv F_{n-1^4} \equiv F_{n+1^4} \equiv F_{n+2^4} \equiv 1 \pmod{F_n}$.

Speed Department

R. Robinson Rowe wants to know:

What kind of book would say that a 10 × 10 square has area 10?

Here is a series of geography questions from George A. W. Boehm (you'd better check your answers on a map):

What is the northernmost state? The southernmost state? The westernmost state? The easternmost state? The first foreign country you come to going directly south from Detroit? The largest city east of Reno and west of Chicago?

Solutions

Here are solutions to problems published in the July/August issue. By mistake (the editors'), the same numbers were also assigned to the problems in the October, 1971, issue, the answers to which will be published next month.

41 How did the declarer win this hand:

	♠ K 9 4 ♥ 8 2 ♦ A Q 10 6 5 ♣ 8 6 2	
♠ Q 3 ♥ Q 10 ♦ J 8 7 2 ♣ K J 9 5 4		♠ J 10 8 6 ♥ A 9 4 ♦ 9 4 3 ♣ Q 10 3
	♠ A 7 5 2 ♥ K J 7 6 5 3 ♦ K ♣ A 7	

Neither side was vulnerable. The bidding:

North	*East*	*South*	*West*
Pass	Pass	1 club	Pass
2 diamonds	Pass	2 hearts	Pass
3 diamonds	Pass	3 N.T.	Pass
Pass	Pass		

West led the ♣5.

Rex Ingraham responds: There is no way the declarer can win nine tricks on this deal if the defenders play properly. You're asking me to guess how they managed to let the declarer romp home with it? How about this: East plays ♣Q to the first trick; off-balance with surprise at winning, he thinks the declarer really wants him to continue the suit. South's ♣7 is to him no promise that West can win more than two additional clubs; therefore he returns ♠J in a scheme to set the declarer down with at least one spade, one heart, and three club tricks. Declarer wins the second trick with ♠K and returns ♥2 from dummy. East's hearts are under the declarer's bid suit; he could hold off but decides to take ♥A at once in order to let West know both that the declarer does not have that valuable card but also that both West, whose hearts are over the declarer's, must defend the suit. After that it doesn't matter what East elects to return. The declarer can win and cash out with five hearts, two spades, two diamonds, and one club for his contract and an overtrick.

Also solved by Philip D. Bell, Winslow H. Hartford, Mrs. Martin S. Lindenberg, Jeffrey A. Miller, Edwin A. Nordstrom, R. Robinson Rowe, and G. Steinitz.

42 Show that for any positive integer n, $3^{2n+1} + 2^{n+2}$ is divisible by 7.

The following is from Winslow H. Hartford: Assume a solution exists for some value of n (as it does for any value you care to check!). Now it can be shown that the algorithm for $n = n + 1$ differs by a multiple of 7 and hence is divisible by 7. For $n = n + 1$, the algorithm takes the form:

$3^{2n+3} + 2^{n+3}$.

The difference can be expressed by:

$(3^{2n+3} - 3^{2n+1}) + (2^{n+3} - 2^{n+2}) =$

$3^{2n+1}(8) + 2^{n+2}(1) =$

$(3^{2n+1} + 2^{n+2}) + 7(3^{2n+1})$.

The first term is equal to a known solution, the second is a multiple of 7; therefore the entire expression is divisible by 7, and a solution exists for $n = n + 1$.

Also solved by Robert W. Baird, Gerald Blum, Charles Bures, Harold Donnelly, Joseph S. Evans, Jo Ann S. Flaun, Richard Jenney, Mrs. Martin S. Lindenberg, John E. Prussing, R. Robinson Rowe, Frank Rubin, G. Steinitz, Clark Thompson, Harry Zaremba, and M. Otto Zigler, VI.

43 Two brothers owned an orange grove. After their oranges were picked, one brother divided them into 39 baskets and found that there were 16 oranges left over. The second brother then took all of the oranges and put them into 56 smaller baskets, finding that there were now 27 oranges left over. What is the smallest number of oranges possible, and what are the next four larger numbers of oranges which fulfill the conditions?

The following is from R. Robinson Rowe: If N is the number of oranges and x and y are the capacities of the larger and smaller baskets, respectively, the given data are expressed:

$N = 39x + 16 = 56y + 27$,

which is a diophantine equation in two unknowns, to be solved in integers. The general solution may be expressed in terms of any integer u:

$x = 29 + 56u$; $y = 20 + 39u$; $N = 1147 + 2184u$,

and the smallest and next four values for N are 1147, 3331, 5515, 7699, and 9883. I noted that for 1147 oranges, the smaller basket would hold 20, filling 56 baskets with 27 left over. The leftovers would have filled a 57th basket with 7 left over. Reading the problem carefully, I interpret it that there were only 56 baskets. But if this was intended for a "catch," that he had plenty of baskets and could fill only 56, then the smallest N would have been 3331; for this many oranges, the baskets would have held 85 and 59, respectively—gargantuan baskets or lilliputian oranges!

Also solved by John Babbitt, Robert W. Baird, Charles Bures, Gerald Blum, Neil Cohen, Harold Donnelly, G. Evans, Winslow H. Hartford, Richard Jenney, Marc Judson, Sanford M. Libman, Mrs. Martin S. Lindenberg, Edwin A. Nordstrom, Frank Rubin, G. Steinitz, Clark Thompson, Paul G. N. de Veguar, Harry Zaremba, Ken Zwick, and the proposer, Warren Himmelberger.

44 The letters of a saying are written in order on squares 1 to 32 of a checkerboard with the usual numbering system. A certain game of checkers might then

be written:

	32 D		31 E		30 I		29 R
28 T		27 S		26 I		25 W	
	24 E		23 N		22 E		21 H
20 T		19 M		18 O		17 H	
	16 W		15 Y		14 B		13 T
12 S		11 R		10 I		9 F	
	8 E		7 H		6 T		5 T
4 O		3 N		2 E		1 B	

1.	R—Y	E—H	10.	F—O	N—B
2.	E—R	H—B	11.	S—W	E—T
3.	F—O	N—B	12.	E—T	W—H
4.	I—H	H—B	13.	T—F	I—N
5.	O—E	I—N	14.	F—O	N—B
6.	T—I	W—H	15.	W—M	I—I
7.	I—H	H—B	16.	Y—O	B—I
8.	B—T	R—W	17.	H—B	S—N
9.	T—F	E—I	18.	O—S	D—H
			19.	D—H	Drawn

The proposer, Walter Penney, supplied the answer; the saying is: "Be not the first by whom the new is tried." His "moves" were:

1.	11—15	22—17	10.	9—18	23—14
2.	8—11	17—14	11.	12—16	24—20
3.	9—18	23—14	12.	2—6	25—21
4.	10—17	21—14	13.	6—9	26—23
5.	4—8	26—23	14.	9—18	23—14
6.	6—10	25—21	15.	16—19	30—26
7.	10—17	21—14	16.	15—18	14—10
8.	1—6	29—25	17.	7—14	27—23
9.	6—9	31—26	18.	18—27	32—7
			19.	3—10	Drawn

Also solved by Mary J. Youngquist.

45 Determine an 8 × 8 upside-down magic square from the 64 three-digit numbers made of the digits 1, 6, 8, and 9.

The following is from Loren L. Dickerson, Jr.: Here are two of an undetermined number of 8 x 8 magic squares of the 64 three-digit numbers specified. These are pan-diagonal, in that all 16 diagonals have the same sum, 5328, as the rows and columns:

111 166 689 691 818 869 986 998
919 961 188 199 616 668 881 896
868 889 996 918 161 186 699 611
666 688 891 816 969 981 198 119
181 196 619 661 888 899 916 968
989 991 118 169 686 698 811 866
898 819 966 988 191 116 669 681
696 618 861 886 999 911 168 189

616 698 881 866 919 991 188 169
818 899 986 968 111 196 689 661
969 911 198 189 666 618 891 886
161 116 699 681 868 819 996 988
686 668 811 896 989 961 118 199
888 869 916 998 181 166 619 691
999 981 168 119 696 688 861 816
191 186 669 611 898 889 966 918

Also solved by R. Robinson Rowe, Harry Zaremba, and the proposer, David DeWan.

Better Late Than Never

Solutions to the following problems have been received:

21 C. N. Galvin
26 E. L. Condon, C. N. Galvin, Jack Groth, and Robert H. Park
34 Andrew Cahn
36 John E. Burchard
37, 40 Raymond Gaillard

Books

James Miller, William G. Denhard

Technology and the Unfreedom of Man

History and Class Consciousness, Studies in Marxist Dialectics
Georg Lukács
Translated by Rodney Livingstone
Cambridge, Massachusetts, The M.I.T. Press, 1971, 356+xlvii pp., $8.95

Toward a Rational Society, Student Protest, Science, and Politics
Jürgen Habermas
Translated by Jeremy J. Shapiro
Boston, Beacon Press, 1970, 132+ix pp., $5.95

Knowledge and Human Interests
Jürgen Habermas
Translated by Jeremy J. Shapiro
Boston, Beacon Press, 1971, 349+viii pp., $7.50

Reviewed by
James Miller
History of Ideas
Brandeis University

A hitherto largely hidden current of European social thought is finally becoming available to American readers. For decades, important investigations by theoreticians and philosophers of a broadly Marxist persuasion have led at best a subterranean existence in this country. But the recent publication of works by Georg Lukács, Jürgen Habermas, Ernst Bloch and Theodor Adorno should help rectify this situation. English-speaking readers may now place into historical perspective the tradition of social criticism whose best-known representative in the United States is Herbert Marcuse.

This tradition is still of interest today in part because it elaborated a far-reaching critique of science and technology during a period when America still innocently upheld the gospel of scientific progress. During the 1920's and 1930's, the "Frankfurt School" of Marxism, whose members included Max Horkheimer, Adorno, Marcuse, Erich Fromm and Walter Benjamin, advanced this critique on two fronts. On the one hand, the methodology of the natural sciences, especially as it found expression in positivist philosophies, was assailed for veiling the methodology proper to the social sciences.

On the other hand, critical investigation into the real social role of technology disclosed the emergence of science and its technological applications as a new constituent element of the general material and spiritual oppression within advanced industrial societies. Whereas Marx had believed technology to be "neutral," Frankfurt's theoreticians perceived that whatever potential for liberation was embodied in man's growing ability to dominate nature also carried with it the possibility of an increasingly efficient domination of man by man. Yet this threat of technology's authoritarian dominion in the service of a repressive ruling order was occluded by the ideology of technological progress: the public celebration of science concealed the fact that key decisions concerning destructive and manipulative technical innovations were made privately by a small group of men.

Social Science: Passive or Active

The twentieth-century Marxist and neo-Marxist critique of science and technology can be examined at its inception and in a current revision in the works of Lukács and Habermas reviewed here. One of Lukács' criticisms in *History and Class Consciousness* focuses on the effect that the ideology of science has on research in the human and cultural sciences. The natural scientific method of inquiry—which elaborates formal laws on the basis of observable empirical regularities—when applied to the cultural sciences transforms social theory into a passive investigation of "pattern-maintenance" and integration that takes for granted the given social reality. From the natural scientific point of view, capitalist society appears as an absolute and "natural" phenomenon, rather than the transient historical phenomenon it in fact is. As Lukács puts it, "the methodology of the natural sciences . . . rejects the idea of contradiction and antagonism in its subject matter."

Yet according to Lukács' Hegelian-Marxian standpoint, the contradictions of capitalism are precisely the aspects that point to the eventual abolition of capitalism in favor of a more humane, less abstractly rationalized society. *History and Class Consciousness,* originally published in 1923, formulated a radical methodology of dialectical inquiry and social practice that served as the philosophical basis for the neo-Marxian theorizing of Adorno and Marcuse; it remains a seminal work.

The latent hostility evidenced in Lukács' attitude to science and technology has been elaborated more explicitly in Marcuse's *One-Dimensional Man.* There technology is seen as providing the "great rationalization of the unfreedom of man," protecting rather than challenging "the legitimacy of domination." Jürgen Habermas, a pupil of Adorno's and the most prominent younger member of the Frankfurt school, defines his position in opposition to that of Marcuse. While Habermas agrees with Lukács and Marcuse on the ideological effect natural scientific modes of inquiry have on social inquiry, he disagrees with any implications that

science could be methodologically other than it is. Through a critical appropriation of C. S. Pierce's pragmatism, he seeks to outline the legitimate domain of scientific research which is interested in dominating nature. In this often brilliant epistemological argument, *Knowledge and Human Interests,* Habermas seeks to found an emancipatory social science of man with an interest in social liberation (see also Habermas' essay on "Technical Progress and the Social Life-World," which appears in the collection *Toward a Rational Society*).

Here Habermas asks, "How can the power of technical control be brought within the range of the consensus of acting and transacting citizens?" Enlightened social action, today more than ever, demands rational reflection on technical innovation: it has become impossible to rely on "the optimistic convergence of technology and democracy" that Habermas believes Marx accepted. Habermas asserts that the attainment of rational reflection is possible only on the basis of "politically effective discussion"; that such discussion does not presently occur can in large part be attributed to social factors that tend both to bureaucratize scientific research and to tie its fate financially to the imperatives of the established order.

A Constant Becoming

Whether it be Habermas' relatively mild reformist socialism or Lukács' apocalyptic communism, even the most abstract theorizing of neo-Marxism impinges directly on the status quo. Much of its importance lies in the comprehension of what Lukács called the "totality," a concept which attempts to grasp humanity's historical situation in terms of those objective tendencies that would allow man to radically transform his given social conditions. Successfully carried through, such an attempt would articulate the implication of each particular aspect of the social whole for the reproduction of the human species through historical becoming. It is from this point of view that Lukács and his successors at Frankfurt have made a unique contribution to the critique of science and technology. For they see the problem of technology in modern society not as an isolated confrontation of science with some nebulous moral conscience that would found a technocratic kingdom of the ethically acceptable. It is, rather, one moment within a larger socio-economic process that, through political struggles and public self-reflection, forms the material domain of man's spiritual self-realization. For Lukács and Habermas, the dilemma of science in modern society cannot be left to find its solution in some laboratory.

Motivation—The Ultimate Problem

Durability and Reliability in Engineering Design
Gilbert Kivenson
Hayden Book Company, Inc., New York, 1971, 186 + xiv pp., $9.95

Reviewed by
William G. Danhard
Associate Director, C. S. Draper Laboratory

Gilbert Kivenson's book goes straight towards its objectives—a broad discussion of durability and reliability which moves quickly from one idea or technique to another. In fact, between the subchapter headings, index and text, *Durability and Reliability in Engineering Design* can be considered a glossary, or even an abridged encyclopedia, of terms, ideas and techniques useful to the engineer/designer who wants to achieve what this book expounds. The contents include good discussions of modes of failure, protection from chemical attack, reliability analysis, wear and life testing, materials and their properties, and joining. To these are added discussions on designing (including designing by computer), material substitution, and use of the computer in adaptive systems.

If anything is missing from this broad view of things to be considered where durability and reliability are involved, it is the listing of a next stage—a fundamental reference library which would include the various technical handbooks to which one might turn for more detailed information. The author's numerous references are drawn primarily from periodicals and, as such, may or may not provide the added detail needed by someone with a problem.

One of the most important aspects of reliability was relegated to the third-from-last page: motivation. That very aspect will prove to be the very same one determining whether any engineer or designer will read Kivenson's book. Does the designer/engineer want his product to be durable and reliable? Does the man or woman on the production line want the same? "It has been found by industrial psychologists that the ultimate problem is related to the motivation of the individual worker. Training and skill alone are not sufficient . . . ." We worry today, in print at least, about the dehumanization of our society, and this abstract issue suddenly comes to life when we come up against the effectiveness of the worker on the production line. Kivenson did not miss the point entirely, but it deserves a bigger play. Even the manufacturer's incentives—economic or retributive—are mentioned at best in a passing way near the end.

Another viewpoint of reliability should also be brought out: reliable performance and long life may have completely different meanings for two different classes of devices or equipment. The housewife is happy with something like ten hours a year from her electric mixer, and the average car owner seems to thrive on 300 hours of service per year from his vehicle. But the manufacturers of the jet engines in passenger aircraft are striving to exceed 16,000 hours between major overhauls.

Though it needs these perspectives of psychology and economics, Gilbert Kivenson's work will certainly make a good addition to the library of any design engineering group. As a basic tooth-cutting indoctrination for the new designer, the book would be a good reading assignment for the boss to lay on; and it also has a few ideas for the old hand. After that, the whole design department needs a good lecture from the marketing department.

Institute Review

Graduate Financial Aid: Can We Keep Enrollment Up?

The problem is simple. One of the most important sources of financial aid for graduate students, federal fellowships and traineeships, is being deliberately curtailed in a change in government policy. M.I.T. graduate students held 745 federally-funded Fellowships in 1969-70 and 764 of them in 1970-71. But this year there are only about 630, and soon there will be very few indeed.

There was a very real danger, says Irwin W. Sizer, Dean of the Graduate School, that M.I.T.'s graduate enrollment might have dropped this year by exactly the number of federal fellowships and traineeships that went away. Other private universities, finding themselves in the same situation, did indeed find their graduate enrollments falling. While the total of U.S. graduate students has increased 2.8 per cent from last year, private universities are down 4.8 per cent and public universities—where tuition is subsidized and expenses are therefore much lower—are up 6.1 per cent.

M.I.T. was lucky; graduate enrollment for 1971-72 is down—but only 1.4 per cent (from 3,296 to 3,250).

New Resources, Traditional Excellence

The most important reason for so small a change is that the Institute, convinced of the ultimate importance of high-quality graduate education, appropriated $552,600 in emergency funds to replace 90 of the disappearing fellowships. But Dean Sizer emphasizes another important factor—the continued and increasing excellence of M.I.T.'s graduate school, particularly as demonstrated in last year's American Council on Education survey (*see* Technology Review *for March, 1971, pp. 66-67).* The 6,000 academic scholars responding to the survey placed M.I.T.'s graduate programs first in the nation in six out of 18 fields.

The emergency fellowships provided at M.I.T. came from the Sloan Basic Research Fund, which is intended as "seed money for research in science and engineering." The effect of diverting part of it to graduate fellowship support might typically be to force a professor to postpone the purchase of a new piece of equipment. Dean Sizer intends to apply to the M.I.T. administration for a renewal of the Sloan money, but "it is not yet clear that it will be granted."

In an effort further to compensate for the loss in federal funding, the Graduate School last spring asked faculty engaged in sponsored research to try to find support for more graduate research assistants through research grants. "They did the best they could on short notice," Dean Sizer reported "but so far there is no significant change."

Other changes in graduate student support have included increases (from four to eight) in Ford Minority Fellowships and in special tuition awards from Institute funds to minority students. But in special support for minority students, Dean Sizer says, "we have just about reached the end of our financial rope."

With its financial aid thus concentrating in the hands of the very poor, M.I.T. faces the spectre of dichotomy: becoming the school of the very rich and the very poor, while those in between are forced to go elsewhere. No one wants that result.

Another group in jeopardy are the foreign graduate students, 28 per cent of the graduate enrollment. Always ineligible for federal fellowships, they have traditionally been supported by other means. But now that everyone is scrambling for what had previously been theirs, they cannot help but lose. A foreign student is typically at a disadvantage, furthermore, in applying for a research assistantship because he is usually less familiar with sophisticated laboratory techniques and American hardware than is his domestic counterpart.

"Move Heaven and Earth"

Dean Sizer says that M.I.T. "will move heaven and earth" to keep from drastically altering the spectrum of students in its Graduate School, and he relies on research assistantships as the best means for achieving this goal. This does not mean a change in the number of teaching assistantships for they are "an important part of our teaching program," says Dean Sizer. But teaching assistants are paid from the same budget as are faculty members, and "you can't fire a professor to hire two graduate assistants."

But will the money become available to increase the number of research assistants? Dean Sizer believes that it will, but he is not sure by exactly how much. In the first place, although research funds seem to be declining nationally, M.I.T. is "getting into exciting new areas that attract federal money and has made a very definite effort to bring in new money to replace cancelled projects. The net result," says Dean Sizer, "is more research dollars on campus at M.I.T."

Large portions of M.I.T.'s research have always been done by graduate students, but not all of it has been charged to the funding agencies. When the agencies are made to fully support the research student, project budgets will be more realistic—and higher. And university research will be more costly to these agencies.

But the agencies may be willing to pay the higher price. Both William D. McElroy, former Director of the National Science Foundation, and Edward E. David, Jr., Sc.D. '50, Science Adviser to President Nixon, have said they believe a proper way to support graduate students is through research grants. The government likes the idea because graduate students will be working on research projects directed toward goals the government has chosen.

Will all these efforts do the job, or shall M.I.T. begin to think of a sharply reduced effort in graduate education? Sizer's enthusiasm falters: "I'm pessimistic, frankly—even though we can certainly keep the quality high, our enrollment may very well go down."

Creative Renewal by an Undergraduate Academic Office

A year has now passed since the Commission on M.I.T. Education released its preliminary report, "Creative Renewal in a Time of Crisis." Though it promised a final report (*see* Technology Review *for January, 1971, pp. 89-97*), the Commission in fact disbanded without publishing anything further.

At least as far as the Commission's proposals on undergraduate education are concerned, that task of specific definition has now fallen to a high-level faculty task force headed by Hartley Rogers, Jr., Professor of Mathematics who is now Chairman of the Faculty. The task force picked up the major recommendations and translated them into concrete proposals—in its own form of creative renewal.

After months of work, the task force presented its report of the December faculty meeting but no immediate action on the proposals was expected. The nature of the proposals themselves was common knowledge as early as September, for the task force saw no need for the kind of secrecy which prevailed prior to publication of the Commission's report.

There will be three proposals in the Rogers report:

☐ Especially in the undergraduate programs, M.I.T. should place more central emphasis on contact between students and faculty members, both individually and in small groups.

☐ M.I.T. should establish an Office of Undergraduate Academic Programs, headed by a Dean of Undergraduate Academic Programs. Here would be focussed the responsibility of the faculty as a whole for the general education of undergraduates; it would provide a continuing intellectual focus on questions pertaining to undergraduate programs and an administrative continuity which is now seen as lacking.

☐ M.I.T. should establish a Division for Educational Research to draw together, support, and coordinate its developing capabilities in the area of educational research.

As a part of its first recommendation, the task force will propose that undergraduates be allowed to spend up to 25 per cent of their time in any semester working "in a non-standard context" with faculty members—a seminar, laboratory, or any other form the student and the professor find "real and important to them both." Professor Rogers has cited the Undergraduate Research Opportunities Program as providing "admirable illumination as to what can be accomplished."

This "seminar-research experience" might also, where appropriate, serve as a vehicle for writing off certain kinds of general institute requirements such as the laboratory requirement. It would be administered by the Dean of Undergraduate Academic Programs.

The other activities of the new Dean and his staff would be working with several standing committees of the faculty to coordinate and communicate innovation in undergraduate education; providing administrative and intellectual help to the faculty in meeting its responsibility to approve, support, initiate, modify, and adopt experimental undergraduate programs; helping the faculty exercise its responsibility to accept, approve, and initiate alternative forms of general institute requirements; maintaining an "overview" of M.I.T.'s academic programs and serving as a source of information on them; and providing an input to the promotion and tenure process, especially on the basis of contributions to the educational program in extradepartmental areas.

Professor Rogers sees the Dean of Undergraduate Academic Programs as "providing a kind of senior management" in the area of undergraduate education; he feels that if the Dean is to succeed, he must be a person "of major ability."

The Division for Educational Research would conduct research and development in the fields of curricula, learning research and cognitive studies, and continuing education. It would have its own faculty (but mostly on joint appointments) and its own students (initially graduate students only) and would serve as a "framework for mounting interdisciplinary efforts in educational research." It would be a division, not a school, because instead of being a collection of permanent departments, "it would have subdivisions varying in form with time."

In its style and form, the Rogers task force stands in sharp contrast with the Commission. "Significantly," wrote *The Tech* Editor Robert Fourer, '72, "the Rogers Task Force is a return to the elite committee method of education reformation. Its six members include one Commission member (Professor Sheila E. Widnall, '60, of Aeronautics and Astronautics), one Department Chairman (Professor Frank Press, of Earth and Planetary Science), one Assistant Department Chairman (Professor Anthony P. French, of Physics), one Dean (Benson R. Snyder, Dean for Institute Relations), and one senior faculty member (Professor Robert G. Gallager, of Electrical Engineering). There are no students; a student advisory group was formed, but at its last meeting only one member showed."

Old Beer and Wine, and the History of Technology, etc.

A catalog the size of a 24-page tabloid newspaper is used to announce departments', laboratories', and miscellaneous plans for January, 1972—the second designated Independent Activities Period in the history of M.I.T.

Participation in the month-long between-the-terms action is optional. For some students, it will be a chance to accelerate programs by receiving academic credit for one-month intensive courses; for some, a chance to make up courses that didn't quite work out in the past; for some, a chance to explore new ideas for which the regular academic terms are simply too crowded; and for some, a chance to goof off more or less constructively. And for perhaps 30 per cent of M.I.T.'s students it will be a four-week ski or Bahamas weekend.

Here are some of the intriguing (both serious and not so serious) alternatives paraphased from announcements in the preliminary list of I.A.P. activities published in tabloid format late in November:

☐ Computer programming for people who are afraid of machines—the basics of computer use with the goal of getting the participant to be able to do something with computers in his or her own field.

☐ Business opportunities in marine resources—a mini-course given by eight members of the faculty in the Sloan School of Management and Department of Ocean Engineering.

☐ Radio writing-acting workshop—studios, tapes, splicing facilities, sound effects, music and engineering talent will be supplied by WTBS; the missing elements are actors and writers.

☐ Coffee house: The Pot Luck Coffeehouse will run more often than usual, with free entertainment. Entertainers needed.

☐ Materials technology developments in aircraft construction, a field trip to visit companies concentrating on developments in composite materials technology.

☐ Air traffic control—field measurements for a simulation study of airport operations.

☐ Application of air cushion vehicles to the transportation of crude oil from the North Slope oil fields of Alaska—a study group.

☐ Gourmet cooking, dependent on finding a kitchen (noncredit, by the Department of Architecture).

☐ Increasing street traffic capacity—a seminar to propose various means of upgrading a major urban arterial to postpone building a parallel expressway for as long as possible.

☐ Construction projects, in which civil engineering students will be attached to project management teams on Boston-area construction projects.

☐ Soviet Union study tours: spend three weeks in Moscow and Leningrad, speaking Russian only or speaking English.

☐ German House: live in the Phi Gam house, speaking only German for three weeks.

☐ Comparative racial history: spend two weeks at the Center for Multi-Racial Studies in Barbados.

☐ Computer animation workshop—learn a computer animation language and work on computer-generated movies.

☐ Automobile bumpers—a research group to answer the question, Do proposed low-speed bumper specifications result in decreased crash protection at high speeds?

☐ Desert island physics: deriving the quantum mechanical properties of atomic, nuclear, and other systems from first principles without resort to props.

☐ Colonial New England beers and wines: an introduction to an experimental methodology used in studying the history of technology.

☐ The Great M.I.T. Boat Race, a study of how much power must be expended in driving a ship through the water.

Not How—But What To Build

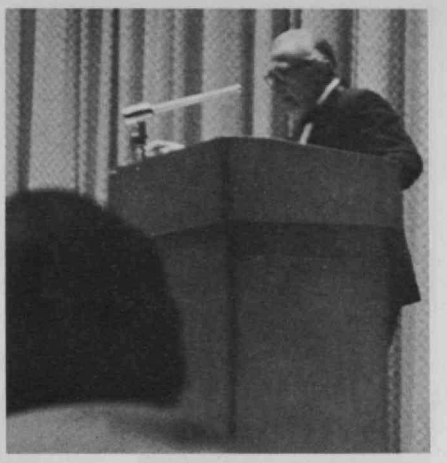
Engineering used to be simple: the question was only to achieve what science makes it possible for man to do.

Now engineering must be more sophisticated: it must comprehend not only what science makes possible but what people really need, says Alfred A. H. Keil, Dean of M.I.T.'s School of Engineering. Indeed, Dean Keil told members of the M.I.T. Club of Boston this fall, engineers now have two new obligations in addition to the traditional requirement for effectively applying scientific principles and industrial experience:

☐ Engineers must now satisfy themselves that their work responds to the real needs of society, not that it fulfills all the complexity that science makes possible.

☐ Engineers must not only foresee the consequences of their work but adjust their solutions so that future results may better fulfill future social need.

The engineer's trap, said Dean Keil, is



His overflow audience, said Paul Tishman, '24, was a "flat contradiction" of the idea that engineers are unaware of the creative arts. He was speaking to over 900 alumni and guests at the Metropolitan Museum of Art in New York for a reception and buffet marking the inauguration of M.I.T.'s new Council on the Arts.

to be so fascinated with ideas and disciplines that he sees only the challenge to do what science renders possible instead of what people need.

For education, said Dean Keil (who took over leadership of the School of Engineering at M.I.T. just six months previously), this means diversification. Students must, of course, continue to learn science, basic engineering, and industrial science—what it takes to build things. Now they must also understand the social, economic, and public institutions through which their work will be used.

And schools of engineering have yet another opportunity, too: to help students in other fields understand how engineers can in fact best meet social needs, so that they as citizens can in turn help technology realize its new destiny.

New Evidence and New Means for Joining Science and Art

A renewed effort to integrate the sciences and the creative arts at M.I.T. was announced at the Metropolitan Museum of Art in New York on November 4, when over 900 alumni and guests attended a reception for which the entire Museum was opened for private viewing for the M.I.T. Alumni Center of New York.

In a formal presentation during the four-hour reception, Paul Tishman, '24, who was Honorary Chairman of the committee for the evening, announced the formation of a new Council on the Arts at M.I.T. and the appointment of Roy Lamson, Class of 1922 Professor of Literature, to be Special Assistant to the President of M.I.T. for the Council. He called the Council "a break-through in the education of the scientist and engineer to art" and the overflow audience at the reception "a flat contradiction of the idea that scientists and engineers are uninterested and unaware of the relevance of the creative arts."

Calling attention to M.I.T.'s present "outstanding" activities in the creative arts, including graphic arts, photography, drama, literature, and music, Dr. Wiesner said he envisioned that the Council would help the Institute achieve "a substantial and coherent group of programs growing out of these present strengths." He takes encouragement, he said, from the increasing public concern for the quality of life, and he hopes that the expressive, appreciative, and creative skills of the artist can increasingly take their place at the Institute beside the dominant deductive skills of the engineer.

Mr. Tishman, who will be Chairman of the new Council on the Arts, described himself as "one who is passionately devoted to the credo that there must be a marriage of art and science." Modern technological developments, he said, "lead us more and more toward the arts, seeking the beauty and insight that can fill our world with meaning."

Thomas Hoving, Director of the Metropolitan, agreed; technology and art will each have deeper perceptions, he said, for one's ability to see the other.

Among those who will serve with Mr. Tishman on the new Council are Mrs. Ida Rubin, Mrs. Julius A. Stratton, and Angus N. MacDonald, '46—all of whom, said Dr. Wiesner, have been principals in the efforts at M.I.T. to stimulate the interaction of technology and art which have now led to forming the new Council.

C.A.E.S.: The First 300

More than 100 engineers, working at their own speed in their own home communities, have now completed self-study courses prepared by the Center for Advanced Engineering Study at M.I.T., and at least 200 more are now enrolled.

C.A.E.S. has completed and is now offering to students four core "refresher" courses in mathematics—Calculus I and II, Probability, and Random Processes. The first part of a four-part course in Colloid and Surface Chemistry with lectures by J. Th. G. Overbeek, Professor of Physical Chemistry at the University of Utrecht, is now in use, and the second section is in preparation.

Those who have finished their courses are almost unanimous in agreeing that the work has been "a worthwhile experience in terms of the time and effort it took," and few wished for academic credit—which is not available for C.A.E.S. courses because of M.I.T. faculty requirements regarding faculty-student contact.

A C.A.E.S. self-study course consists of a series of lectures on film or videotape with accompanying photographs of the lecturer's blackboard made at the end of each lecture, a study guide to indicate assignments and supplementary readings and to present problems related to the lectures, and a textbook to be used just as any student in a conventional college course uses one. Most of the students who answered questionnaires after finishing C.A.E.S. courses last year said these materials were at least adequate, and many were more enthusiastic; no local tutor or instructor is needed, they said.

But some were critical, especially of the texts; and John T. Fitch, '52, Manager of Self-Study Subject Development at C.A.E.S., reporting these first results to the New England Research and Engineering Meeting this fall, suggested that C.A.E.S. students may be more perceptive in their view of textbooks than college-age students. Among the comments: ". . . some of the message was lost in the rigor employed to put the subject across." "I thought the text was much too formal and stilted. I considered it very poor . . ."

Though they are arranged for self-paced study, most C.A.E.S. courses are given through company programs. Two experiments this year seek to change that pattern: M.I.T. alumni in the New York City area are studying Calculus Revisited in weekly sessions at the M.I.T. Alumni

Center of New York, and the same program will be offered on WGBX (Channel 44) in Boston beginning on January 5, 1972. In this case, lectures by Herbert I. Gross, Senior Lecturer in Civil Engineering at M.I.T., will be broadcast twice weekly in the afternoon and repeated in the evening, and in the afternoons viewers will be able to telephone questions to Mr. Gross; those who wish to pursue the course pay $75 for study guides, supplementary notes, photographs, and the privilege of taking a final examination for a certificate of completion in June, 1972.

After 4,300 Successful Matches

Evelyn B. Yates, known for 30 years as a friend in time of greatest need by thousands of M.I.T. alumni, has retired from duties as M.I.T.'s Alumni Placement Officer.

In 20 years since the Korean War, more than 160,000 positions were listed with the Alumni Placement Office and some 23,000 M.I.T. graduates registered for employment with the Office. Out of this heterogeneous mixture, Mrs. Yates succeeded in making nearly 4,300 matches.

Throughout this period, the character and volume of her mail accurately reflected the supply-and-demand situation for scientists and engineers. In periods of recession, such as the early 1950's and now, the number of jobs available fell and the number of job applicants rose; in the mid-1960's the number of vacant positions recorded with the Alumni Placement Office was high and the number of alumni applicants lower. Wishing for a mechanism to dampen the cycle must have been perennial.

Mrs. Yates first came to M.I.T. in 1942 as assistant to the late Nathaniel McL. Sage ('13), who was then in charge of placement as Director of the Division of Industrial Cooperation. Almost continuously since then, alumni placement activities have been her principal interest. Many industrial personnel officers have paid tribute to her activities, including one who recently wrote, "Among the many excellent college placement offices throughout the country, I have always found yours to be the most helpful and effective."

Following Mrs. Yates' retirement, alumni placement work—a part of the M.I.T. Office of Career Planning and Placement—is being coordinated by Miss Kathleen A. Gallery, Miss Linda Stantial, and Jay W. Hammerness; Miss Gallery has been serving as Assistant Alumni Placement Officer. Robert K. Weatherall is Director of the Office.

An alumnus has written, "I would like to express special thanks to Mrs. Evelyn Yates and her Alumni Placement Bureau for the excellent job she is doing." Nothing unusual; indeed, during 20 years of her management of the Alumni Placement Office since the Korean War nearly 4,300 alumni found new jobs through activities managed by Mrs. Evelyn B. Yates, who retired on October 30. (Photo: Margaret Foote)

"The chief obstacle in the way of wider ranging reform and innovation in teaching is the schedule arrangement based on units of one hour," says John G. King, Professor of Physics at M.I.T. Dr. King (right) poses above with Merrimon Cuninggim, President of the Danforth Foundation, during ceremonies at which he received Danforth's $10,000 Harbison Award for Gifted Teaching.

Harbison Teaching Award

John G. King, '50, Professor of Physics at M.I.T., is one of ten winners of 1971 E. Harris Harbison Awards for Gifted Teaching given by the Danforth Foundation of St. Louis, Mo. The awards, designed to honor "articulate, passionate teachers . . . with an (outstanding) ability to impart enthusiasm and to teach the very essence of their subjects . . .," carry $10,000 tax-free grants to be used by each winner at his discretion in furtherance of his academic career; they are among the most prestigious given in the U.S. for university-level teaching.

Dr. King is identified with M.I.T.'s concepts of "concentrated study" and the plan for "corridor laboratories"—displays with which students can perform simple experiments when more elaborate, formal laboratory facilities are closed.

Pursuing his ideas for concentrated study, Dr. King has conducted a number of classes on an intensive basis—full-time study of a single subject for a short period of time, in contrast to the conventional classes in a subject scheduled throughout an academic term. His purpose, he says in a report published by M.I.T.'s Education Research Center, is to give students "a long enough continuous period for them to become immersed in the subject to a far greater degree than is usual," and also to eliminate "the common experience of haste, of 'not having enough time' and of continual grappling with schedules."

Dr. King joined the M.I.T. faculty two years after receiving his Ph.D. in physics here, and he has been Professor of Physics since 1965. In addition to the Harbison Award, he held the Millikan Lecture Award (1965) and a Sloan Teaching Award (1961), and in 1961 he won an apparatus design award of the American Association of Physics Teachers (1961).

William Arrowsmith, formerly Visiting Professor at M.I.T. who is now University Professor at Boston University, also won a 1971 Harbison Award.

Institute Professor

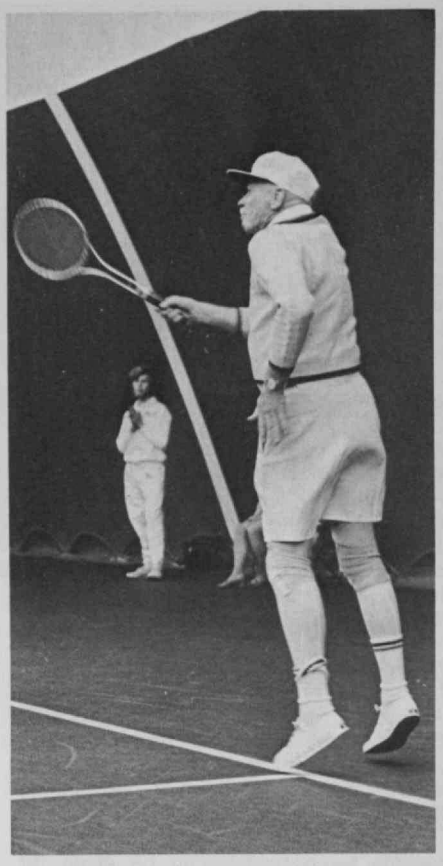
Edwin R. Gilliland, Sc.D.'33, Warren K. Lewis Professor of Chemical Engineering, has been named to the distinguished rank of Institute Professor. President Jerome B. Wiesner, announcing the new appointment, recalled Dr. Gilliland's service as Head of the Department from 1961 to 1969, Director of the Undergraduate Seminars Program since its inception, and Deputy Dean of the School of Engineering in 1945-46; and his significant contributions through research on the fractional distillation of petroleum, the production of synthetic rubber, and water purification processes.

Dr. Gilliland came to M.I.T. in 1931 to work on his doctorate following graduation from the University of Illinois (B. S. 1930) and the Pennsylvania State University (M. S. 1931). He was appointed to the faculty in 1936 after service as a research fellow and instructor. Dr. Gilliland has been a member of the President's Science Advisory Committee, holds the Walker and Lewis Awards of the American Institute of Chemical Engineers, and is a member of both the National Academies of Science and of Engineering.

Dreyfus Professor

George H. Buchi, a distinguished organic chemist who has been a member of the M.I.T. faculty since 1951, has been named Camille Dreyfus Professor of Chemistry; he will continue under the new appointment teaching and research in the synthesis and structure of natural products—including terpenes, alkaloids, and toxins.

Professor Buchi came to the Institute from the University of Chicago following study in chemical engineering at the Eidgenossische Technische Hochschule in Zurich. He has held visiting appointments at several institutions, is a member of the National Academy of Sciences and a fellow of the American Academy of Arts and Sciences and of the British Chemical Society, and holds the Ruzicka Prize (1957) of the Swiss Chemical Society and the Fritzsche Award (1958) of the American Chemical Society.



Tennis had a very special day at M.I.T. on November 5, when Jasper B. Carr, '16, brought members of his family and of his class as well as four tennis "greats" to the Institute for the dedication of the indoor tennis courts which he made possible for the Institute. There were formalities with Vic Seixas, Mr. Carr, and Howard W. Johnson, Chairman of the Corporation (left to right, above), and then Mr. Carr himself tried the new courts in the inaugural match (right). (Photos: Sheldon Lowenthal, '74, and Margaret Foote)

Tennis, Anyone?

Tennis was invented in England in 1873, and for two-thirds of the 97 years since then it has been the favorite sport of Jasper B. Carr, '16. As an undergraduate he was a member of the tennis team and a Vice President of the M.I.T. Tennis Association. Fifty-five years later—nearing 80 and still asking, "Tennis, anyone?"—he returned to M.I.T. late this fall to play in the inaugural tennis match in the new J. B. Carr Indoor Tennis Center.

But the word for the day, said Jerome B. Wiesner, President of the Institute, was really, "Tennis, everyone!" Five years ago a survey revealed that M.I.T. was "hopelessly at the bottom" among New England colleges in its tennis facilities. With Mr. Carr's gift of the four-court Indoor Tennis Center and two additional outdoor courts, the Institute's tennis capacity has increased 50 per cent and M.I.T. has been catapulted into Harvard's league in terms of tennis facilities per thousand students.

The dedication on November 5 brought four of America's leading tennis players to the Institute—Straight Clark, Mitchell Gornto, E. Victor Seixas, Jr., and James Shakespeare. Vic Seixas teamed with Mr. Carr for the inaugural match against David B. Carr and Mitch Gornto; David Carr had joined with his father to make possible the new Center. Later the professionals staged singles and doubles exhibitions, showing some of the most spectacular tennis ever seen at M.I.T. (Fire regulations unfortunately limited the exhibition audience to a number of Mr. Carr's classmates and family friends, members of the M.I.T. tennis team, and Institute dignitaries.)

At the end of the day Mr. Carr received what he never got as an undergraduate, despite an active career in M.I.T. athletics: his M.I.T. letter "T" in tennis from Gregory P. Withers '72, team Captain.

Underwood-Prescott Award

Seventy-five years—almost to the day—after Samuel C. Prescott ('94) of the M.I.T. Department of Biology and William L. Underwood of the William Underwood Co. presented to M.I.T.'s Society of Arts findings from their joint research leading to new standards of safety in food canning, the award which honors them was given at the Institute to Louis Rey, head of Corporate Research and Development for Nestle Alimentana, S.A., Vivey, Switzerland.

The presentation was made on the occasion of the annual Underwood-Prescott luncheon, at which Dr. Rey received his award and honorarium, followed by a symposium on recent and prospective food science developments in which Dr. Rey, Arthur E. Humphrey, S.M.'60, Head of the Department of Chemical Engineering at the University of Pennsylvania, and Bruce A. Drew, Research Associate in Applied Mathematics for the Pillsbury Co., were speakers.

George A. Seybolt, President of William Underwood Co., said the award provided by the Company to a recipient designated by an M.I.T. faculty committee seeks to recognize new contributions to critical subjects in food supply and processing fulfilling the social responsibilities of food scientists in improving the quality of life worldwide.

Dr. Rey, formerly a member of the faculty at the University of Dijon, France, is internationally recognized for his early work in food freezing, freeze drying, and related uses of cryogenics in the food industry. He has also been responsible for cooperative research between the Nestle Co. and the various petroleum companies on single-cell protein foods.

Harvard-M.I.T. Computer

Ever since October 22, computer jobs submitted for batch processing at the Harvard Computation Center have been run on a computer at M.I.T. The two schools have invested in a new computer system which is expected to save each about $500,000 per year.

The heart of the system, according to Robert H. Scott, '64, Director of the M.I.T. Information Processing Center, is an I.B.M. System 370/155 at M.I.T. which serves eight remote entry points around the two campuses. It also processes jobs which are handled through a System 370/145 at the Harvard Computation Center. (The 370/145 also serves the Cambridge Electron Accelerator.) The two computers communicate through three high-speed telephone lines which will soon be replaced by a microwave link.

The new system replaces two System 360/65's, one at each school. It will save money by reducing unutilized computer capacity; but more than that, it represents the beginning of a far-reaching effort to achieve long-term savings and intellectual cooperation in the two universities' computer services.

"To get used to working together," Mr. Scott said, "we chose batch processing because it has a high probability of success." The next step, which will probably involve time-sharing services, is not yet completely settled: "We have to make this work first."

The I.P.C. provides more than half M.I.T.'s computer services. As a service facility, its goal is to charge users just enough to cover expenses.

Urban Executives Program

M.I.T's fifth Program for Urban Executives, conducted with the advice and counsel of the National League of Cities, U.S. Conference of Mayors, and the Inter-

national City Management Association, is scheduled for June 4 through 30, 1972. Its purpose is to help prepare "key managers who will influence the development and implementation of municipal, county, and state policy," according to Peter P. Gil, Associate Dean of the M.I.T. Sloan School of Management.

Professionals now working in urban affairs who are between the ages of 35 and 45 are eligible to apply. The four-week program will cover principles of both management and technology applied to urban administration; there will be classes in the application of technology to urban problems, the management of economic resources, planning and controlling financial resources, labor relations and personnel administration, and managerial information systems for planning and control.

Further information and applications are available from Robert M. Ilfeld, '44, Associate Director for Executive Programs, in the M.I.T. Sloan School of Management.

Beavers and Citations

Award of seven Alumni Association Bronze Beavers and of Presidential Citations to five alumni organizaticns was announced at the October meeting of the Alumni Advisory Council.

Winners of the Bronze Beaver—the highest award which can be given for alumni service to M.I.T.—were:

☐ Arnold A. Archibald, '28, possessor of "an enviable record of service to M.I.T." after "many years of dedicated alumni activity." Mr. Archibald has been President of the M.I.T. Club of Western Pennsylvania, Chairman of the Alumni Fund's Leadership Gifts Council in Pittsburgh and now of the Pittsburgh-Area Alumni Fund Council, and a member of the Alumni Fund Board and of the Visiting Committee of the Department of Metallurgy.

☐ James W. Barton, '39, whose "perennial assistance, advice, and devotion to M.I.T. affairs . . . have earned him the title of 'Mr. M.I.T. of Seattle.' " Mr. Barton has been Honorary Secretary, Educational Counsellor, officer and Director of the M.I.T. Club of Puget Sound, and a regular worker for the Alumni Fund and the Second Century Fund.

☐ William S. Edgerly, '49, who has through many activities "given new vitality and direction to strengthening the Institute." Mr. Edgerly's most recent service has been as Chairman of the Alumni Advisory Committee to the M.I.T. Commission on Education; he has also served on Visiting Committees, on the Long-Range Planning Committee, on the Alumni Club Advisory Board, and on the Alumni Association Board of Directors; he has been Vice President of the Association and an officer of the M.I.T. Club of Boston.

☐ Samuel A. Groves, '34, who has brought "quiet leadership to the financial and personnel needs of the Association and to the area of alumni communications." Mr. Groves is currently Chairman of the Nominating Committee of the Association, and he served as its President in 1965-66.

☐ Donald A. Hurter, '46, "originator of ideas as well as implementor, (who) has a unique ability to bring together, motivate, inspire, and lead his fellow alumni." Mr. Hurter has been active in alumni affairs almost since his graduation, including membership on committees "too numerous to list"; he has been class officer, club officer, and Alumni Fund worker, and to him goes credit for much of the planning for alumni seminars which are now a major factor in the Association's program.

☐ Breene M. Kerr, '51, compiler of "an extraordinary record of alumni accomplishment in a brief 20 years" following graduation from M.I.T. The record began when Mr. Kerr was elected President of the M.I.T. Club of Tulsa just seven years following graduation; since then he has been a member and officer "in virtually every local and national alumni activity," including Visiting Committee and the Corporation itself.

☐ Irwin W. Sizer, Dean of the Graduate School at M.I.T., whose "unselfish, devoted service on behalf of alumni . . . have won him a lasting place in the annals of his adopted alma mater." Dean Sizer was elected an Honorary Member of the Association in 1964 in recognition of his generous leadership in planning the first alumni seminars, and he has continued to be active in all aspects of alumni affairs.

1971 Presidential Citations were given to:

☐ The Alumni Fund Area Council in Washington, D.C., for its work in support of the 1971 Alumni Fund.

☐ The Washington, D.C. Regional Conference Committee for its success in sponsoring the conference of March, 1971.

☐ The 1971 Entrepreneurship Workshops Committee, sponsors of the series of seminars and workshops on new business opportunities throughout the U.S. in 1970-71.

☐ The Class of 1921, for outstanding support of the Institute through fund-raising and reunion activities in its 50th year.

☐ The San Francisco Educational Council, to recognize its outstanding contribution through interviewing San-Francisco-area high school students.

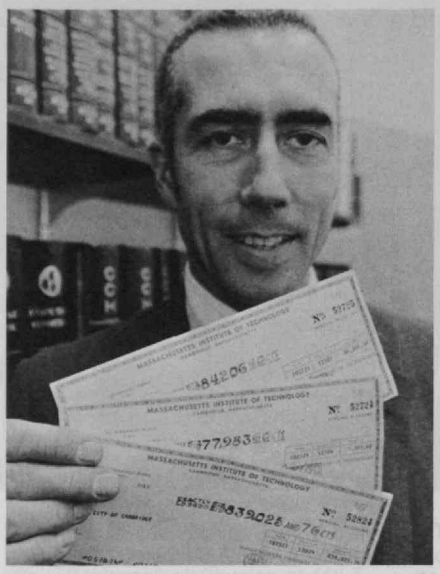
$1 Million in Taxes

Three payments of real estate taxes made to the city of Cambridge by M.I.T. late in November—a total of over $1 million—assured that the Institute would continue to be the third largest source of revenues for the city. The November payments included:

☐ $839,025.76 of real estate taxes on M.I.T.-owned properties not used for educational purposes; these include land formerly occupied by the Simplex Wire and Cable Co. which will be redeveloped for housing and industrial use and several parcels of land now being developed with "turn-key" housing.

☐ $84,206.40 of real estate taxes on the so-called Epsco Building, now being used for research and storage.

☐ $77,983.60 of real estate taxes on a leased building at 75 Cambridge Parkway occupied by the Charles Stark Draper Laboratory.



When Cambridge real estate taxes were due late in 1971, the M.I.T. News Office made this picture of Kimball Valentine, Jr., Assistant to the Treasurer, to emphasize that the Institute is not exactly tax-exempt. The three checks cover payments on M.I.T.-owned properties not used for educational activities and are part of a total of over $2 million in real estate taxes and payments in lieu of taxes which the city of Cambridge gained from M.I.T.-related properties in 1971.

In addition to these, M.I.T. paid additional amounts to Cambridge in 1971:

☐ Some $296,000 in voluntary payments in lieu of taxes on properties recently on the tax rolls but now used for educational purposes and hence tax-exempt; M.I.T. makes such payments to ease the transition from taxable to tax-free for the city.

☐ $182,870 paid by the Northgate Community Corp., an M.I.T.-sponsored real estate activity designed to improve housing stock for use by long-time Cambridge residents and members of the M.I.T. community.

☐ Some $500,000 paid in taxes by tenants in buildings owned by M.I.T. for investment purposes.

☐ An advance payment of $125,000 made to the city in the summer of 1971 to help it meet operating expenses without borrowing against anticipated tax income.

Fall Sports: Fair to Good

Though many observers of the athletic scene bemoan it, the usual way to assess the varsity season is through the wins-losses columns. On that basis, fall 1971 was successful: a composite total of at least 27 wins, 11 losses.

Cross-country was at the top of the list—11 wins, 2 losses; the record was the more remarkable because there was no superstar. The team was consistently paced by Robert B. Myers, '72, and John E. Kaufmann, '73, but the pair managed only three individual victories

in their eight races this fall.

The soccer team, winning only five out of 13, was involved in eight shutouts, but it was at best a mediocre season. Meanwhile the sailing team emerged from the fall season with the New England championship—the Fowle Trophy—but claimed no better than fourth place in the national Schell Regatta. Two coed invitational regattas among New England schools completed the season, and M.I.T. teams took first-place honors in both.

In its second year as a varsity sport, the water polo team won 11 out of 17, defeating Brown but losing to Harvard, and took sixth place in the New England tournament. *Tech Talk* called it "an encouraging sign for so young a sport."

M.I.T. still has only one real tennis star—William D. Young, '74, who won both singles and doubles (with Kevin Struhl, '74) championships at a Brandeis tournament early in the fall. It was his second sweep of the tournament in as many years.

The Serious—and Not So Serious

It is a moment when society seems to hold a different view of science. What does that mean for M.I.T. as a university centered in science? A harder role, perhaps; but we cannot turn away from the goals to which we are committed, Walter A. Rosenblith, Provost of the Institute, told nearly 100 high school guidance counselors at M.I.T. late this fall.

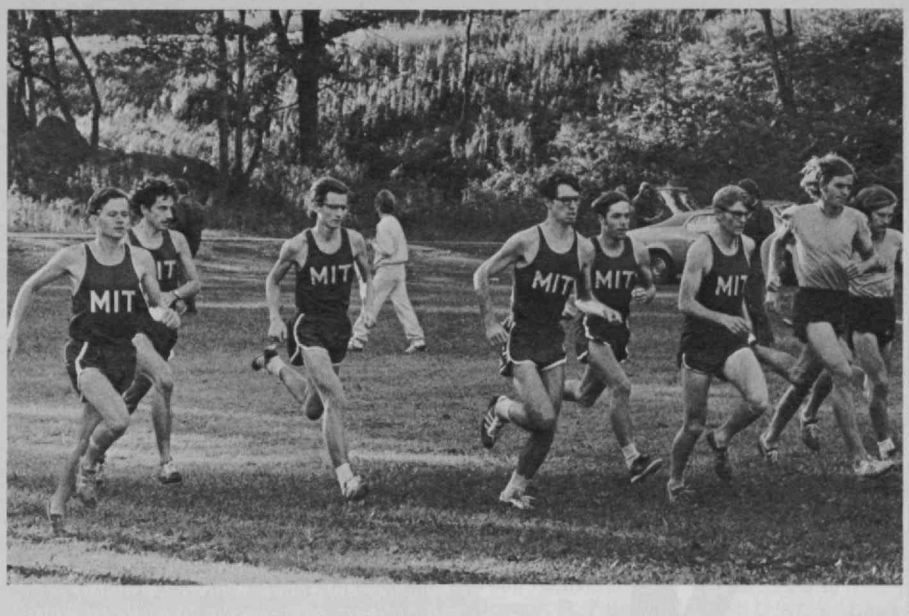
"We must be our own implacable critics," he said. We must face the paradoxes that others also sense, and we must make special efforts to understand and help resolve them. For example, "we must work very hard to learn how to apply technology to public systems as well as to public goods," Professor Rosenblith declared.

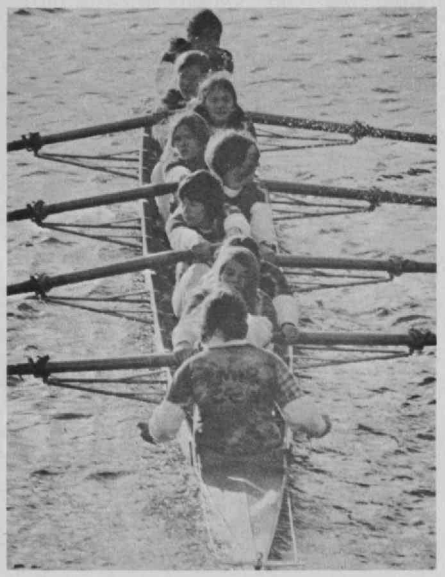
What does this mean for high school students and their counselors? We know that unemployment figures "loom large in the choices of high school students," said Professor Rosenblith. But the students must have longer time bases. "No case can ever be made for refusing to use—or find—knowledge," he declared—hence the prospect for continuing and increasing dependence upon science, engineering, and technology-based work in the future.

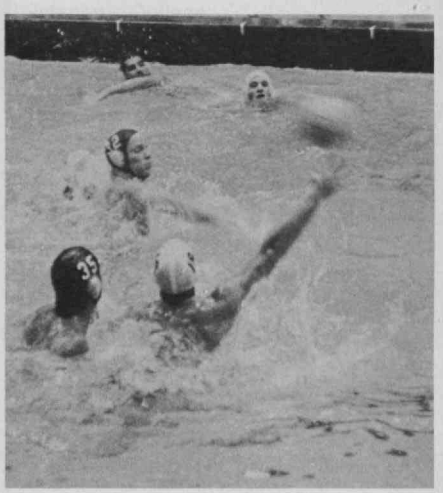
And what will students who take this longer view of values find at the Institute? A panel of faculty assured them that students here continue to expect—and receive—excellent preparation in fields that "seem to us at the top of technology's agenda." And the students, increasingly sensitive to a gap between what technology can do and what it does, are finding their own ways to make their educational experiences ever more relevant.

. . . and their own ways to make life more enjoyable, too, according to a panel of four undergraduates on student activities. The two coeds on the panel found themselves the center of friendly curiosity: What's it like to be a girl at M.I.T.?

It's "exciting," said Katherine Swartz, '72—who, as it turned out, is living in







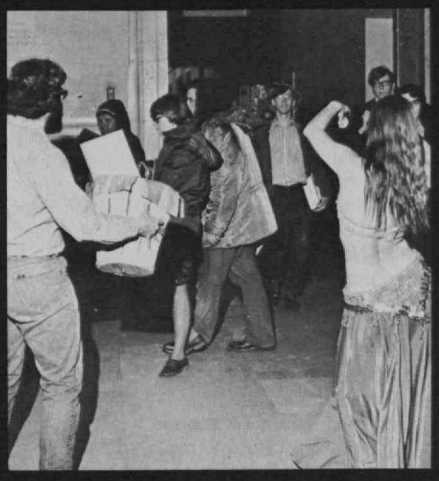
If ever in the past two years of rapid campus change there was a softening of student interest in sports, that time is past, says Ross H. Smith, Director of Athletics. The 1971 fall season brought record numbers of intercollegiate and intramural athletes to Briggs Field, the Charles River, and the Alumni Swimming Pool—including a women's eight-oared shell and hard-fought intramural football. (Photos: Bradley C. Billetdeaux, '72, David M. Tenenbaum, '74, and Sheldon Lowenthal, '74, from The Tech*)*

The Gallery

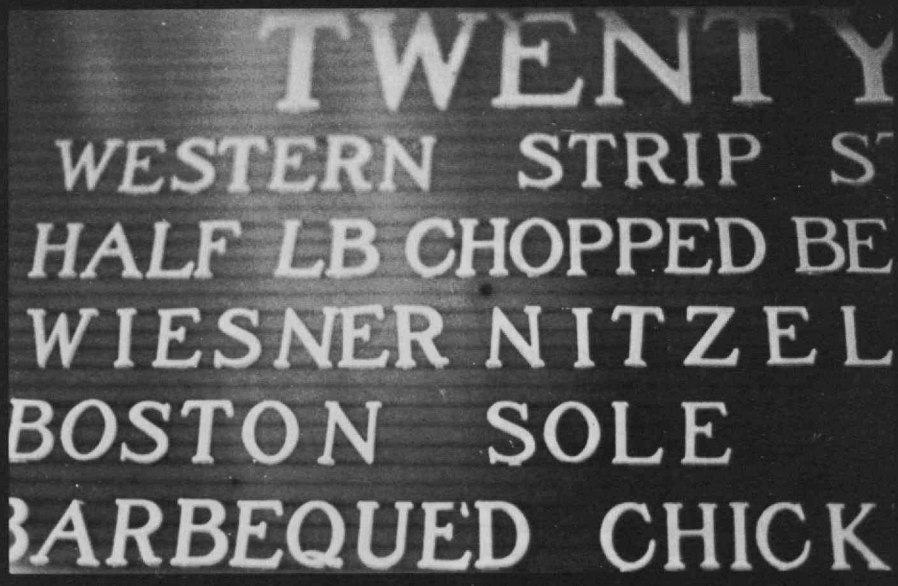
(Above) *Andrew J. Rubel, '74, may have been the first exponent of the current unicycle fad at M.I.T.—but he has lots of company now. (Photo: Margaret Foote)*

(Below) Artist Lynda Benglis and several assistants spent two weeks late this fall creating polyurethane foam sculptures in the Hayden Gallery. The process began with the erection of plastic-sheet covered frames; then came the creation —sometimes to large student audiences (who watched through gallery windows because of fumes); and finally an exhibition of the awkwardly animal-shaped sculptures which resulted.

"You're now entering the Ethical Suicide Parlor," said the guide to his masked visitors as they approached the Green Building early this winter. Obviously no ordinary sight-seeing tour, these were members of the cast of "Between Time and Timbuctoo," a Kurt Vonnegut story adaptation being filmed by Boston's Channel 2 for a special N.E.T. Playhouse program. (Photo: Margaret Foote)



Old grads who seek evidence that everything at M.I.T. is normal in 1971 will find this picture at once reassuring and perplexing. Reassuring, because the belly-dancer in the Building 10 lobby is extolling the virtues of a student publication. Perplexing, perhaps, because the artiste in question is an M.I.T. undergraduate, Beverly Seavey, '73, and she is promoting Thursday, *the radical left student weekly tabloid.*



(Above) No typographical error, this: it's the newest specialty of the house at the Twenty Chimneys, Student Center grill room.

coed Senior House this year. The best thing about it is "having guys as good friends just as girls would be anywhere else. It's a challenge to get to know guys as well as I do here," she said: and the coed dormitory is the best thing of all: " . . . like living in a family, only more stimulating conversation than with just girls."

Lynn Mahoney, '72, agreed: "It's really great being a girl at M.I.T."—partly at least because a coed at the Institute is taken seriously for her interest in a career, not just for her interest in going to college.

But Gregory C. Chisholm,'73, isn't willing to make it quite so simple. There are bad things as well as good. "We don't have any idyllic situations here," he said; it's not really like a family—just a group that gets together with mutual interests. And because there is such a group, he said, there's always the chance of someone being left out.

Upper Atmosphere Research

Plans for a $13-million upper atmosphere observatory to study the relationship between energy and weather, radio communications, and other phenomena miles above the earth have been completed by a consortium of six universities, and funds for the project are now being sought from the National Science Foundation and from the National Research Council of Canada.

The universities, organized as the Upper Atmosphere Research Corp., are M.I.T., Rice University, the University of Illinois, the University of Pittsburgh, Pennsylvania State University, and the University of Western Ontario. The Observatory would be located along the U.S.-Canadian border near the Great Lakes, where it would be under a low-density "trough" in the ionized layers of the upper atmosphere formed by the earth's magnetic field.

New "incoherent" radar techniques will be used to track and study rarefied gases and particles in the ionosphere, 50 to 6,000 miles above the earth. The earth's weather is largely determined by winds in this region, and radio communications are heavily influenced by radio and magnetic and electric conditions. Though satellites and rockets provide grief glimpses of ionospheric conditions, a facility which can operate continuously on a 24-hour basis is needed.

John V. Evans of M.I.T.'s Lincoln Laboratory is Project Director for U.A.R.C.; its President is William E. Gordon, Dean of Engineering and Science at Rice University, and preliminary studies for the Observatory have been completed at the University of Illinois by Sidney A. Bowhill, Professor of Electrical Engineering.

Jamieson Re-elected

J. Kenneth Jamieson, '31, Chairman and Chief Executive Officer of Standard Oil Co. (New Jersey), was elected to a second five-year term as a member of the M.I.T. Corporation during that group's annual meeting at M.I.T. on October 8.

Mr. Jamieson, a native of Medicine Hat, Alberta, Canada, was associated with Imperial Oil Co., International Petroleum Co., Ltd., and Humble Oil and Refining Co. before joining Standard of New Jersey in 1964. He has been a member of the M.I.T. Corporation since 1966 and as Chairman of its Visiting Committee for the Department of Chemical Engineering has played a key role in the development of research and teaching in that field at M.I.T. He is also a member of the Corporation's Development Committee, and he has previously been a member of its Visiting Committee to the Department of Nutrition and Food Science.

The winner of this year's Ugliest Man on Campus contest was Paul Wagoner, '74 (top), running as "Great Court Jester." His supporting cast is (left to right) Don Arkin, '72, John Mangold, '72, and Frank Spahn, '72

Not Ugly—Just Silly

Every Fall the Alpha Phi Omega service fraternity asks the Institute what is the ugliest thing around—and the community responds by dredging up the most disgusting specimens it can muster for the Ugliest Man on Campus contest. Past winners have included an alligator, a pretty coed, and more traditionally ugly candidates who campaign unshaven and in filthy costumes.

This year the voting reached a record high (a vote cost 1¢, anyone could vote as often as he liked, and all the proceeds were contributed to CARE) with a total of $3083.83 collected. The winner was Paul Wagoner, '74, running in a fool's costume as Great Court Jester, with $605.54—that's 60,554 votes. With the slogan, "I'm not ugly; I'm just silly," Wagoner falls into the category of unorthodox uglies. Runners-up were the more standard Dave DeBronkart, '72, said to "use Crisco hair tonic," with $563.17, and "Ugleon" (a specimen entered by Chi Phi fraternity), claimed to be so ugly that "Fellini gagged, sidewalks spit on him, even coeds look good, blind dates (the kind with dogs) turn him down," with $514.83.

In the last hour of voting, Wagoner and DeBronkart were running neck and grimy neck. DeBronkart and some of his friends made a last-ditch effort to collect votes from his dormitory (East Campus) by mugging anyone who had not yet contributed. But thanks to his fraternity brothers (Phi Beta Epsilon), Mr. Wagoner clinched the victory one second before the official end of voting by producing from up his sleeve a $100 bill.

Individuals Noteworthy

Aaron Finerman, Professor of Engineering and Computing Science, State University of New York at Stony Brook, to Manager, Jet Propulsion Laboratory, Office of Computing and Information Systems . . . **Robert L. Cleland,** S.M.'51, to Professor of Chemistry and **John A. Menge,** Ph.D.'59, to Professor of Economics, Dartmouth College . . . **James R. Mahoney,** Ph.D.'66, to Associate Professor of Applied Meteorology, Department of Environmental Health Sciences, Harvard School of Public Health . . . **Robert L. Gluckstern,** Ph.D.'48, to Vice-Chancellor for Academic Affairs and Provost, University of Massachusetts . . . **Joseph R. Fahey,** S. J., Ph.D.'67, to Dean, Holy Cross College . . . **Charles W. Merriam, 3rd,** Sc.D.'58, to Professor and Chairman, Department of Electrical Engineering, University of Rochester . . . **Russell R. Pfeiffer,** Ph.D.'63, to Chairman, Department of Electrical Engineering, Washington University . . . **Richard E. Stoiber,** Ph.D.'37, to Frederick Hall Professor of Mineralogy, Dartmouth College . . . **A. W. Schlechten,** Sc.D.'69, to Professor and Head, Department of Metallurgical Engineering, Colorado School of Mines . . . **John P. Cutler,** M.A.R.'42, to Professor, School of Architecture and Environmental Design, California State Polytechnic College.

M.I.T. Appointments: **Malcolm G. Kispert,** '44, to Institute Secretary . . . **James D. Bruce,** Sc.D.'64, to Associate Dean, School of Engineering . . . **Charles L. Miller,** '51, to Professor, Civil Engineering and Director, Urban Systems Laboratory . . . **Louis B. D. Braida,** S.M.'65, to Assistant Professor and Executive Officer, Electrical Engineering . . . **Ned J. Block,** '64, to Assistant Professor, Physics . . . **Carl E. Hewitt,** '67, to Assistant Professor, Civil Engineering . . . **Martin L. Shooman,** '55, to Visiting Associate Professor, Electrical Engineering . . . **Joseph Ferreira,** '67, to Assistant Professor, Urban Studies and Planning . . . **Terry A. Winograd,** Ph.D.'70, to Assistant Professor, Electrical Engineering . . . **Richard C. Larson,** '65, to Assistant Professor, Electrical Engineering and Urban Studies . . . **William L. Porter,** Ph.D.'69, to Dean, School of Architecture and Planning and Professor of Architecture and Urban Planning . . . **Ole S. Madsen,** Sc.D.'70, to Assistant Professor, Civil Engineering . . . **Howard H. Brown,** '56, to Visiting Associate Professor, Physics . . . **James H. Porter,** Sc.D.'63, to Visiting Associate Professor, Chemical Engineering.

To **Leo Beranek,** Lecturer at M.I.T., the first Gold Medal Award of the Audio Engineering Society . . . **Joseph Libsch,** '40, to Fellow of American Society for Metals . . . to **Albert R. Gurney, Jr.,** Associate Professor, M.I.T. Department of Humanities, a 1971 Drama Desk Award . . . to **Hermann A. Haus,** Sc.D.'54, the 1971 Western Electric Fund Award

V. Fischer

W. L. Huber

F. S. Carpenter

A. C. Schroeder

for teaching and research . . . to **Donald R. F. Harleman,** Sc.D.'50, the Karl Emil Hilgard Hydraulic Prize, American Society of Civil Engineers . . . to **Alfred C. Schroeder,** '37, the 1971 Vladimar K. Zworykin Award of the I.E.E.E. . . . to **C. Allin Cornell,** M.I.T. Professor of Engineering, the Walter L. Huber Civil Engineering Research Prize, American Society of Civil Engineers . . . to **John G. King,** '50, the E. Harris Harbison Award for Gifted Teaching, Danforth Foundation . . . **Eric Reissner,** Ph.D.'38, to Fellow of American Institute of Aeronautics and Astronautics . . . **Luis A. Ferré,** '24, the Hoover Medal, from the A.S.M.E. . . . to **Charles S. Draper,** '26, the Rufus Oldenburger Medal, A.S.M.E. . . . **Philip P. Crimmins,** '52, to Fellow, American Institute of Chemists . . . to **Kenan E. Sahin,** '63, the Salgo-Norean Award for excellence in teaching . . . to **Charles J. Neumann,** '46, the Department of Commerce Silver Medal . . . to **Warren M. Rohsenow,** M.I.T. Professor of Mechanical Engineering, the Max Jakob Memorial Award of the A.S.M.E. and the A.I.C.E. . . . to **Vannevar Bush,** E.G.D. '16, an Honorary Doctor of Engineering degree, Dartmouth College . . . **Robert F. Flood,** '35, to Board of Trustees, Rosemont College . . . **Warren G. Bennis,** Ph.D.'55, to President, University of Cincinnati . . . **John P. Longwell,** Sc.D.'43, to Senior Scientific Advisor, Esso Research and Engineering . . . **Victor Fischer,** M.C.P. '50, to Board of Governors of American Institute of Planners.

The 1971 Bronze Beaver Award of the M.I.T. Alumni Association to **Arnold A. Archibald,** '28, **James W. Barton,** '39, **William S. Edgerly,** '49, **Samuel A. Groves,** '34, **Donald A. Hurter,** '46, **Breene M. Kerr,** '51 and **Irwin W. Sizer,** Dean of the Graduate School.

Paul E. Gray, '54, to Director, National Shawmut Bank of Boston . . . **John W. Focke,** M.AR.'68, to Vice President, Caudill Rowlett Scott . . . **F. Scott Carpenter,** '44, to Vice President, Cabot Corp. . . . **Harold E. Thayer,** '34, to Chairman of the Board and Chief Executive Officer, Mallinckrodt Chemical Works . . . **Norman A. Jacobs,** S.M.'59, to President, Amicon Corp. . . . **Frank Shaw,** S E.'68, to Executive Vice President, Coleman Company, Inc. . . . **Gary Brooks,** '55, to Vice President of Marketing, Scott Graphics, Inc. . . . **Alexander Squire,** '39, to President, WADCO, Hanford Engineering Development Laboratory . . . **Carle C. Conway,** '53, to Senior Vice President, Ultronic Systems Corp. . . . **Richard V. Warden,** S.M.'59, to President, I.T.T. Decca Marine Inc. . . . **Kenneth N. Davis,** '46, to Executive Vice President of Systems and Services, General Instrument Corp. . . . **David F. Springsteen,** '54, to Vice President, Stone and Webster Securities Corp. . . . **Nathan Cohn,** '27, Leeds and Northrup Co., to Board of Franklin Institute.

M.I T. Appointments: **Edwin R. Gilliland,** Sc.D.'33, to Institute Professor and Warren K. Lewis Professor of Chemical Engineering . . . **Ira Dyer,** '49, to Head, Department of Ocean Engineering . . . **Jean P. Leinroth,** Jr., Sc.D.'63, to Visiting Professor, Department of Chemical Engineering . . . **Ronald W. Wolff,** '55, to Visiting Associate Professor, Sloan School of Management . . . **James L. Kirtley, Jr.,** '68, to Assistant Professor, Department of Electrical Engineering . . . **James W. Beatty, Jr.,** Ph.D.'60, to Visiting Associate Professor, Department of Chemistry.

Deceased

Paul R. Parker, '03, October 25, 1971
Robert N. Hoyt, '09, June 2, 1971
George T. Palmer, '09, August 1971
Ernest L. Patch, '10, October 10, 1971
Eldred E. Besse, '11, October 13, 1971
Robert O. Wood, '11, July 1, 1971
Ralph Riddell, '12, n.d.*
Edgar H. Weil, '13, October 1, 1971
Ralph Hart, '15, July 21, 1971
Harold A. Moxon, '16, April 20, 1971
Ralph J. Crosby, '18, July 31, 1971
Samuel A. Brunelle, '19, September 1971
Homer V. Howes, '20, October 28, 1971*
Raymond C. Fisher, '21, August 13, 1971*
Carl W. Hammond, '21, September 1, 1971*
Raymond S. Bond, '22, August 30, 1970
Charles R. McCutcheon, '24, September 17, 1971
Wilbur W. Criswell, Jr., '26, October 30, 1971*
Leland W. T. Cummings, '26, n.d.*
Lucien R. St. Onge, '26, February 1971*
G. Richard Peterson, '26, October 24, 1971*
William Wraith, Jr., '26, July 6, 1971
John F. Healy, '27, September 14, 1971
John A. Carrollo, '28, September 17, 1971
George R. Lang, '28, October 30, 1971
Francis L. Stetson, '28, August 24, 1971
Joseph F. Clary, '29, September 16, 1971*
Carl G. Wennberg, '29, December 27, 1970*
Edwin H. MacEwan, '33, September 22, 1971
William D. Hope, '41, May 29, 1971
Basil Staros, '41, October 28, 1971
Joseph H. Holloway, '52, September 25, 1971*

* Further information in Class Review

Brewer Engineering Laboratories Inc.

Consulting Engineers
Experimental Stress Analysis, Theoretical Stress Analysis, Vibration Testing and Analysis, Specialized Electro-Mechanical Load Cells and Systems, Structural Model Testing and Fabrication, Strain Gage Conditioning and Monitoring Equipment.
G.A. Brewer '38,
Marion, Massachusetts 02738
(617) 748-0103

Capitol Engineering Corporation

Consulting Civil Engineers

Robert E. Smith '41,
Edward W. Boggs '56

Dillsburg, Pennsylvania 17019

Cleverdon, Varney and Pike

Consulting Engineers

Structural, Electrical, Civil, Heating and Ventilating, Air Conditioning, Plumbing

112 Shawmut Ave.
Boston, Massachusetts
02118

Charles Nelson Debes Associates, Inc.

Engineers and Consultants

Structural, Electrical, Mechanical, Acoustical, Industrial, Commercial and Municipal Projects

C.N. Debes '35

915 East State Street
Rockford, Illinois

Fay, Spofford & Thorndike, Inc.

Engineering for Government and Industry

Ralph W. Horne '10, Howard J. Williams '20, William L. Hyland '22, Edward C. Keane '22, Francis J. Turnbull '25, Eugene B. Lunden '27, William J. Hallahan '32, Fozi M. Cahaly '33, George M. Reece '35, Max D. Sorota '50, and Paul J. Berger '50

11 Beacon Street, Boston, Mass. 02108

Haley & Aldrich, Inc.

Consulting Soil Engineers

Foundation Systems Engineering Engineering Geology—Seismic Surveys Site Evaluation & Development Consultation for Design & Construction Earth Dam Design
H. P. Aldrich, Jr. '47 D. E. Reed '64
M. C. Murphy '51 J. J. Rixner '67
W. H. McTigue '54 E. B. Kinner '70
238 Main Street, Cambridge, Massachusetts 02142

The Ben Holt Co.

Engineers and Constructors
Planning and Feasibility Studies
Design and construction of facilities for the Energy Industries

Ben Holt, '37
R. E. Hodgson, '51
D. H. Cortez, '68

521 East Green Street
Pasadena, California 91101
(213) 684-2541

Kuljian

Engineers·Constructors
Utility-Industrial-Public Works Power Plants (Nuclear·Fossil·Hydro), Transmission Systems (HV & EHV), Industrial & Processing Plants, Highways & Expressways, Airports & Facilities, Government & Institutional Buildings, Military Installations
H.A. Kuljian '19, A.H. Kuljian '48

1845 Walnut Street, Philadelphia, Pa. 19103. Tel.: (215) 561-5300

Harold A. McCrensky Associates, Inc.

Management Consultants

Work Standards; Incentive Plans; Management Controls; Standard Costs

H. A. McCrensky '38, President
J. L. Gould HBS'37, Vice President
G. Beesley '39, Vice President
H. E. Jans '52, Senior Consultant

Park Square Building
31 St. James Avenue
Boston, Mass. 02116
Telephone: 617-542-2640

Mueser, Rutledge, Wentworth & Johnston

Consulting Engineers

Foundations for Buildings, Bridges and Dams-Tunnels-Bulkheads-Marine Structures-Soil Studies and Tests-Reports, Design and Supervision

William H. Mueser '22,
Philip C. Rutledge '33

415 Madison Avenue
New York, New York 10017

Polysciences, Inc.

Research, Development, and Consultation in the Fields of Polymers, Monomers, Life Sciences, and Medical Plastics.

B. David Halpern '43

Paul Valley
Industrial Park
Warrington, Pa.
(North of Philadelphia)
(215) 343-6484

Maurice A. Reidy Engineers

Foundations and Soil Mechanics
Structural Designs, Buildings, Bridges

101 Tremont Street
Boston, Massachusetts 02108

Stearns & Wheler

Civil and Sanitary Engineers
Consulting Engineers

Sewerage Drainage and Flood Control, Water Supply and Distribution, Water and Waste Treatment, Municipal Engineering, Refuse Disposal, Fire Protection, Airports

W.O. Lynch '47, S.G. Brisbin, '50
A.G. Wheler '51, J.S. Grumbling '55

10 Albany Street, Cazenovia, New York 13035 (315) 655-8161

Alan Wofsy & Associates

Developing structures and space for business in California

Alan Wofsy, MCP '67

150 Green St.
San Francisco, California 94111
(415) 986-3030

Class Review

95

My 98th birthday was a pleasant occasion and I appreciated receiving cards from Tyrrell Cheney, Dike Arnold, *Technology Review* and the Alumni Association as well as many others.

A happy and healthy New Year to all.—**Andrew D. Fuller,** Secretary, 1284 Beacon St., Brookline, Mass. 02146

96

Charles Gilman Hyde, Professor Emeritus of Sanitary Engineering at University of California in Berkeley died in Ross, Calif., on September 21. He was born on May 7, 1874 in Yantic, Town of Norwich, Conn., and enrolled in Course XI at M.I.T. As an undergraduate he was active in the college publications serving as associate editor of the *Technique*, as editor-in-chief of *The Tech* and also as president ('94-'95) of the New England Intercollegiate Press Association. Charlie Hyde also found time to belong to several clubs, Delta Kappa Epsilon fraternity and to serve the class as senior president.

For four years after graduation he was an engineer with the Massachusetts State Board of Health. He then went to Pennsylvania where he was in charge of the Spring Valley Testing Station in Philadelphia and later carried out a water supply investigation for the state. In 1905 he became Professor Hyde of the University of California, where he remained until after World War II. During World War I he was a major in the army, ultimately serving in the office of the Surgeon General in Washington.

In addition to his teaching duties, Hyde served the university as Dean of Men in 1926-28 and in 1932 was one of a committee of four to study the health and sanitary conditions affecting steerage passengers between the Orient, Hawaii and the West Coast. For over sixty years he was a consultant engineer on many water supply, sewage disposal and other sanitary and hydraulic problems.

In 1901 he married the late Margherita Isola of Newton, Mass. He is survived by three daughters, Mrs. Margherita H. Dunn and Mrs. Hellen H. Gibbs of Berkeley and Mrs. Katharine H. Williams of Tiburon, one grandchild and five great-grandchildren.—**Clare Driscoll,** Acting Secretary, 2032 Belmont Road, N.W., Washington, D.C. 20009

98

It is Happy New Year time again. May this coming year be filled with many blessings for **Alvan Davis, Bob Lacy, George Newbury, Walter Page** and **Joe Riley.** May the '98 Honorary Member, **Dr. George Harrison** be also included in receiving best wishes for happiness in 1972. We would like to hear from him.—**Mrs. Audrey Jones Jones,** Acting Secretary, 232 Fountain St., Springfield, Mass. 01108

99

Every one has heard that Disney World (15 miles from Orlando, Fla.) opened on time on October 1. This is not news. But when your Acting Secretary, his wife and family became early visitors to be greeted at Disney World by Mickey Mouse, Donald Duck, Pluto and the rest, we were thrilled that such beauty and skill could be accomplished in so short a time. It is a great tribute to Walt Disney, its founder and those who continued to execute his dreams.

The day selected for the visit, October 8, was our daughter's birthday and what better place to celebrate it! As you can imagine, it is impossible to explore this extravaganza in a single day. So when six o'clock came, our feet and legs told us it was time to adjourn to the Polynesian Hotel for the birthday dinner. So, we took the monorail to the hotel, which is part of the Disney complex but is located just outside the park so as to be available for folks who are not Disney World visitors.

Outside the hotel, which is on a lake, the view is most pleasing, but inside, from the second floor balcony, you look down on an exotic tropical garden and fountain. The dining room menu makes a specialty of delicious Polynesian food, correctly served. While we were eating, in came a group of Polynesian entertainers in their native costumes. The girls, from Hawaii, Tahiti and New Zealand, sang and perfectly executed the hula and many other South Pacific dances.

The weekend of October 22 will be given over to the official dedication of Disney World. Right now, as I look at our TV, many of the stars of screen and stage are debarking from their plane to view or to assist in the production of the 90-minute nationwide TV showing which will be aired on October 29.

At the conclusion of the birthday, we felt that the day and evening had been most enjoyable. With best wishes to all—**Norman E. Seavey,** Acting Secretary, Apt. 514, Lucerne Towers, Orlando, Fla. 32801

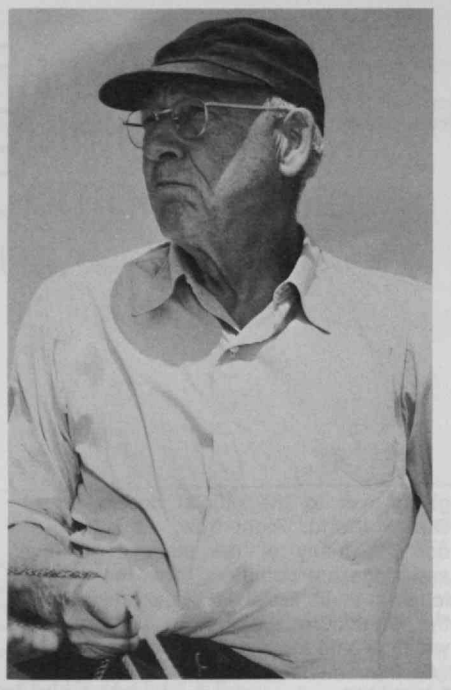
03

Our fortunate remaining classmates are definitely enjoying their tranquil living, fostered of course by Florida and Texas temperatures. However, in New England we are now witnessing a picturesque carpet of leaves on our highways caused by recent cold rain and wind squalls.

Since our recent exhibition of historical souvenirs on Alumni Day, along the corridor of the main building, I chose to add a few for the M.I.T. Archives and have received a very nice letter of appreciation from Professor E. Neal Hartley, the curator. May I suggest to you classmates to do likewise in order to retain M.I.T. history which might otherwise be lost.—**John J. A. Nolan,** Secretary-Treasurer, 13 Linden Ave., Somerville, Mass. 02143

05

Recently while digging out trash (and treasures, Ruth says) I came across some relics of the old days on Boylston Street, for instance my Class Cane and Class Pipe. Does anyone remember how we cherished them for a time? I was then too young to smoke a pipe; now I am too old, for I stopped several years ago just as a matter of good common sense. If we have a pipe smoker in the class who will use it carefully, I'll gladly part with it. As to the cane, I think I will save it for my old age. Then there was a card from Hotel Brunswick, suggesting that I attend "chapel" occasionally. Also the cardinal and grey mortar type hat we used in the big Nantasket Reunion, and many other mementos bringing back fond memories. You fellows probably have discarded most of these long ago, but we, alas or alack, were and are a saving family.



A sailing enthusiast "ever since he was big enough to hold a tiller," Prince Sears Crowell, '05, (above) is shown with his sailing family (above right) Prince S. Crowell, Jr. and Prince S. Crowell, 3rd. (Photos by Dorothy I. Crossley)

Lacking a class agent, it might appear that our class contributions to the Alumni Fund would suffer, but the last report of the 1970-71 Campaign Fund shows that we made the largest contribution of any class up to 1907 and that the number of contributors, 22, was also the largest. That is 70 per cent of the class. In memory of Bob McLean, who started this ball arolling, let's try to better this percentage a bit next year.

The magazine section of the *Boston Herald* of September 5, 1971, carried a 36-inch column about **Prince S. Crowell** of Woods Hole, Mass., titled "Just knocking around with an 89-year-old Prince." It showed the above picture of Prince at the helm, holding the ropes, and part of his yachting (and racing) family in his new fiberglass C.C. "Elf", Prince Sears Crowell, Jr., at the ropes, and Prince Sears Crowell, 3rd, skipper. The boom is homemade by "gluing three pieces together and then cutting to shape a P.S.C. job."

This 36-inch column telling of his passion for sailing is deserving of printing in full, but space does not permit. Prince, who will celebrate his 90th birthday this Christmas Eve, has sailed his 18-foot Knock-abouts from Woods Hole since 1906 and has been sailing "ever since he was big enough to hold a tiller." This year he made one concession to modern technology—a fiber-glass boat. "I sailed my wood 18-footer 'Imp' until last year," Prince said. "They were towing all the Knockabouts to the Nationals, but they wouldn't tow the 'Imp.' They said she'd pull apart. After all she's the oldest one, built in 1929." There are a dozen witicisms and many "sailing tricks" which brought Prince to his championships mentioned in this article, which I wish I could bring to you. Tell you what. I'll have this article mimeographed and a copy sent if the demand is sufficient. Someone should write a book on "Prince Sears Crowell, Cape Cod's Skipper."

A letter from **Bill Spalding,** Course III, says that he and Alice got as far north as Rhode Island, where the rest of the family from Maine came down for a family reunion. Apparently neighbors so taunted Bill about their sea-going ancestors that Bill had the opportunity of bragging about his going to sea from New Bedford at the age of twelve on the last (?) voyage of the whaler "Morning Star." He returned the next day with the pilot, thus "cutting short a career that might have kept me from joining M.I.T." And the U.S.A. would have missed a good miner.

Sam Seaver, Course XIII, and his wife recently celebrated their fiftieth anniversary with 48 kin, including 14 grandchildren attending. Sam reports a year and a half of sickness and pleasure. His doctor must be a whiz, because he prescribes travel to cure Sam's ailments. During the 1970-71 winter season, Sam with his wife and son, apparently the driver, motored from Markham, Ontario, to Florida, Key West, etc., and back home along the East Coast. His doctor found him so much better that he prescribed another trip, so they motored to the West Coast through Colorado, New Mexico, El Paso, then "did the Grand Canyon, several other canyons, on west through Las Vegas, Fresno, and Sacramento, then up to Vancouver and home. The trip did me a lot of good." Man, Sam, I've written a lot of items about the virility of '05 octagenarians, but when I think of driving to Boston, I phone a daughter to come and get me. . . . **Roy Allen** reports, "no more long auto trips for us, otherwise well."

Izzie and **Charlie Smart** have just urged us to attend Charlie's 90th birthday party on November 19, a gala celebration, but I am afraid we must renege. Just as we decide to taper off, some very interesting thing allures. Our list of nonagenarians is increasing—**George Prentiss** on November 27, **Hub Kenway** on December 1, **Prince Crowell** on December 24. I missed notice of Sam Seaver arriving at 90 on September 14.—**Fred W. Goldthwait,** Secretary, Box 231, Center Sandwich, N.H. 03227; **William G. Ball,** Assistant Secretary, 6311 Fordham Place, Bradenton, Fla. 33505

06

How time creeps up on us—faster and faster as the years go by. Tempus Fugit. The interval between letters from classmates gets longer and longer too. If it is heartwarming to receive such a letter, imagine the joy of having a classmate come to *see* you. We had that pleasure last October when **Bob Rose,** Course XIII and Anne came from Marblehead to make a call. While Marion and Anne chatted, Bob and I recalled old times and I showed him some of my "memorabilia." I am sorry I did not think to show him the group picture that Bob took in 1961 at a class dinner which I believe was held at Smith House in Cambridge. Present at that dinner were 14 wives and 19 men. That picture has been on my desk ever since. I have been going through my files lately and most of the contents have been scrapped. However, I am keeping the reports that I receive from the Alumni Fund, and as Acting Class Agent I try to acknowledge, with thanks, all donations to it. From those reports I sometimes spot a change of address: **Freeman M. Scales,** Course V, was a resident of Amherst, Mass., for years and I believe is now living in Rhode Island, at 2 Mary Jane Lane in Newport. Marion and I celebrated our sixtieth wedding anniversary late in October.—**Edward B. Rowe,** Secretary-Treasurer, 11 Cushing Rd., Wellesley Hills, Mass. 02181

07

Walter B. Kirby has sent the following news about his most interesting and active career: "After leaving Tech we soon lose track of our classmates, and wonder where they are and what they have accomplished. With that in mind, the following is a brief of my architectural history.

"When I was young I attended a mechanical drawing class at the Y.M.C.A. and evening classes at the Boston Architectural Club, and from time to time worked in several architectural offices in Boston and New York. While at Tech

I worked on competitions on the Brigham Hospital drawings, and later on for Henry Bacon on the drawings for the Lincoln Memorial in Washington. In 1907 I was given a scholarship to take fourth-year advanced architectural design. Those completing the course were eligible to compete for the Traveling Fellowship of one year of travel and study in Europe. I was awarded the scholarship in 1910 and when in Rome I learned that the American Academy accepted scholarship men if there was a vacant studio. So I remained in Europe for a second year and having a studio to work in, I was able to make many rendered drawings of buildings and details of the classical and renaissance periods. I was also able to receive criticisms of my watercolor sketches. Returning to the states I was honored with a bronze medal from the Department of Architecture 'for the high quality of work done for the Department as Traveling Fellow in 1910-1911.'

"I practised architecture in New York from 1912 until 1930 when I moved my office to New Canaan, Conn., where I remained until my retirement in 1952 at age 67. During that time I had many commissions in Connecticut, Massachusetts and New York. For a few years I was associated with Vitale, Brinckerhoff and Geiffert, Landscape Architects, designing the estate of Mt. Walley in Brookline, Mass., consisting of a large Italian villa, formal gardens, farm group gate lodge, etc. We designed many formal gardens for estates throughout the country, including a stone boat landing and greenhouses for W. H. Walker in Great Barrington, Mass., cascade gardens, loggia and tea house for B. F. Jones in Sewickley Heights, Pa., and plans for a monumental formal garden for John J. Rascob in Wilmington, Del.

"Later on in my own office I designed the estate of Pepperidge Farm for Henry A. Rudkin in Fairfield, Conn. This consisted of a stone residence, farm group and gardens, later made famous when Mrs. Rudkin developed the Pepperidge Farm Bread in her kitchen. Several years later I designed the Pepperidge Farm Bakery in Norwalk, Conn., which is a U-shaped building into which the bakery's ingredients were received at one end, stored, processed, kneaded, baked, cooled, and packaged to emerge in cartons and be shipped from the other end of the building.

"While in New York, to get some outdoor exercise, I joined Squadron C in Brooklyn which had a large horse farm in Huntington, L.I. Squadron members were privileged to stay at the farm and ride the horses through the then beautiful riding country. In 1916 we were called into service and sent to Texas and incorporated into the regular U.S. Cavalry, taking part in the final U.S. Cavalry Regiment review by General Pershing and General Funston. During maneuvers at Hidalgo, a rifle was fired with the muzzle not far from my left ear and I have consequently been deaf ever since.

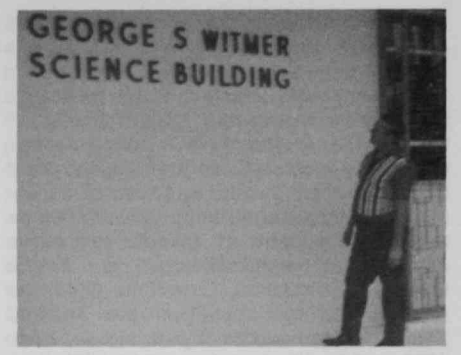
"During World War II I worked for the navy in the office of Voorhees, Walker and Smith, on drawings for several buildings for the Brooklyn Navy Yard. I was a member of the Fairfield County Hunt Club and of the Ox Ridge Hunt Club in Darien, to keep up my riding and exercise. In 1952, upon my retirement, I designed and built a house in Lakeville, Conn., where I still reside and have taken up landscape painting as an avocation. The New Canaan Historical Society has requested some of my architectural photographs and landscape paintings for their archives." We are very grateful to Walter for his continued interest in communicating news for his 1907 classmates.

Mrs. Sara Denison, widow of Orville B. Denison, '11, has sent a most kind and encouraging letter congratulating the reappearance of the 1907 class news column. Mrs. Denison, whose husband was 1911 Class Secretary, was able to witness first-hand for many years the difficulties that the duties of Class Secretary entailed. We appreciate Mrs. Denison's encouragement and we know that, like her, many others are pleased to see the 1907 notes again, but the initial response to our plea for news has waned. Please keep the '07 column thriving. Start off the new year by sending your news to—Kathy Sayre, Class Notes Editor, Technology Review, M.I.T., Room E19-430, Cambridge, Mass. 02139

08

Rather than let an edition pass without class news I will volunteer a brief history of the work of **Joseph W. Wattles, 3rd,** during the past 63 years. When we graduated, the federal efficiency was at a very low ebb. I found work at the Saco-Lowell Shops in Newton, setting up cotton mill machinery. Soon after I transferred to the F. W. Bird and Son paper mills in East Walpole to assist Mr. George Wyman in constructing and equipping a new factory for the manufacture of fiber cases. From there I transferred to the Stanley Works in New Britain, Conn., working in the office of the cost department of this large hardware concern.

The Boston Edison Company was then going into the steam heating business and I again transferred back to Boston as a clerk in this new department. From a meager beginning operating three small private boiler plants, overseeing their interconnection with street steam mains, and the supply of steam for other buildings along the street. This system grew to include the big Stuart St. steam generating station and a grid of steam mains supplying the entire city. In discontinuing the small private electric plant generally, including hydraulic elevator installations, it was necessary to make comparative engineering reports of existing operating costs and the saving with central power and heat. This work lead to the establishment of a Commercial Engineering Division of the sales department of which I became the head. This new division soon included all factories, hospitals and pumping plants within the territory served by this great company. Hundreds of engineering reports were made resulting in the adoption of central station power with underground electric supply. The high tension underground power lines in duplicate extended to the factory substation and served to provide power and lighting for the entire town where the factory was located.



New science building at Trinity Prep School, St. Petersburg, Fla., named in honor of George Witmer, '09.

After 30 years serving in this capacity with six engineers and a secretary, a serious change became necessary. My father then in the sizing business for cotton mills had a heart attack and passed away. I had to give up the commercial engineering work with the Edison Company and take over the sizing business, going back to M.I.T. to study chemical and mill engineering. During the following 20 years in the sizing business the New England cotton mills either went out of business or moved south where the cotton grew. The prosperous business of the early days soon dwindled away as the mills moved south. The cost of shipping the heavy sizing south became prohibitive, and the sizing business had to be abandoned. I retired in 1960 and have since wintered in Florida and back to New England for the summer.

Those members of '08 registered for the President's Inauguration on October 5 were Leo Loeb and Joe Wattles.—**Joseph W. Wattles,** Secretary, 26 Bullard Rd., Weston, Mass. 02193

09

In the class notes early in 1969 we told of **George Witmer** living in a health center in St. Petersburg, Fla., where he was "well taken care of." In fact, he was feeling so well he said "all this watching over can be a nuisance. Call the nurses off." He quoted from a friend who had surgery for a broken leg and had several other disabilities. He asked her, "What is the worst disease?" and she replied, "Old age, because there is no cure for it." Later he told of having given a science building to the Trinity Preparatory School in St. Petersburg and he mused that even so no one would ever know anything of "George Witmer." However, this accompanying photograph shows the entrance to the completed George S. Witmer Science Building with the name in bold letters. We congratulated George on the honor and the fact that his name will be perpetuated indefinitely. We well know of George's past generosity, not only to M.I.T. but to many other worthy causes.

We have received several notes from classmates giving us news about themselves. From **Dwight W. Sleeper,** Newport, Vt.: "In my 84th year I am still traveling to various parts of the United States in the service of the various corporations who retain me to advise them in the protection of their assets, and loss of earnings, and then I contribute all I earn from this to the support of schools and education of my grandchildren." . . . From **Edward P. Chapman,** Cleveland, Ohio, in response to the appeal of the Alumni Fund: "I was struck by a stroke late 1970 and had to turn my accounts to the bank. I seldom know how much money is available. The enclosed check . . . is all I feel I can give. Good luck!" . . . From **Herbert H. Palmer:** "The older I become and with the limitations in getting about from place to place, my loyalty to M.I.T. and the Class of 1909 continues to be a delight." . . . From **Laurence Shaw,** Cotuit, Mass.: "Lost my wife April 25, 1971." The class has expressed its sympathy to Laurence. As we have stated earlier, he has almost never missed a class reunion or an Alumni or Homecoming Day. We missed seeing him at our luncheon this past June. . . . **Harold Paine** graduated from Brown University before entering M.I.T. He was captain of the Brown hockey team and was a top player on the M.I.T. team. We can, therefore, well understand the news item which he sent us from Florida: "Beat M.I.T. at hockey 2-0 when at Brown. Next year, beat Brown 2-0 when at Tech."

In the October-November notes we reported the death of **Edward L. Ryerson** in Chicago and told briefly of his career. Since that time the following further information came to us: "Edward L. Ryerson, 84, civic-minded chairman of the immense Inland Steel Co. between 1940 and 1953, died in Chicago. Though he once claimed to resent the idea of being introduced or publicly identified as a representative of big business, he was one of the steel industry's most prominent and articulate spokesmen. After his 1953 retirement from Inland Steel Ryerson's continuing participation in numerous Chicago community organizations earned him the title 'Mr. Welfare'."

We received the notice of the death of **Howard H. Dole** of 4 Walker St., Portland, Maine, on June 9. In our records there is no information as to his career since leaving M.I.T.—**Chester L. Dawes,** Secretary, Pierce Hall, Harvard University, Cambridge, Mass. 02138

10

I am sorry to advise the class members that **Erford M. Potter** died on August 10, 1971.

Jack Babcock has sent in the following professional biography of Jim Tripp who died in Greensboro, N.C., on July 26, 1971, after a brief illness. "**James G. Tripp** was born in Chicago, Ill., and took the civil engineering course in the class of 1910 at M.I.T. For a few years he was in the construction supply business in Southern California and was also operating his own engineernig design service. But in 1917 he entered the field of 'heavy construction' which was to be his life work until his retirement in 1970. From 1917 to 1930 he served as a contractor for himself or as general superintendent for prominent contractors in the construction of large dams in the western part of this country. In 1931 he joined Merritt, Chapman and Scott and M. C. Whitney, first as construction manager and then as vice president handling many construction bids on such projects as Hoover Dam, Panama Canal work, Mississippi River docks and dams and dredging and bridge foundations.

"In 1937 Jim opened his own consulting service for contractors, developing bids for clients for many large dams, water supply tunnels, etc. World War II took him back into the field work which he always liked best. During that period he served as operating manager for the U.S. Maritime Commission on building concrete tankers and for large contractors building naval bases and steel plants. After the war Jim again went into business as a consultant to contractors on preparation of bids and onsite advice on construction plant and methods. He carried on this work until his retirement. In this work he was involved in large and complex construction projects throughout the United States and many foreign countries. Jim wrote the section on 'Concrete Batching, Mixing, Placing and Curing' for the *Handbook of Heavy Construction.* He also contributed articles on construction equipment and use to several engineering publications.

"Jim was proud of his membership in the 'Moles' (an association of engineers and contractors engaged in heavy construction) and received his 25-year membership award in 1970. He was also a Life Fellow of the American Society of Civil Engineers. While living in New York City after World War II he was an active member of the M.I.T. '1910' group who lunched together quite often. He was one of the most loyal members of our class and attended our five-year reunions whenever possible. He will be greatly missed by his classmates. He is survived by his son, also a civil engineer in the field of heavy construction, and his family with four grandchildren."—**Herbert S. Cleverdon,** Secretary, 112 Shawmut Ave., North Weymouth, Mass. 02191

11

In addition to the information in the class notes for April, 1970, the following is taken from the *Dartmouth Alumni Magazine* for February, 1970: "**Edward Kenway** was instantly killed December 10, 1969, when struck by an auto. He was crossing the road to get his mail. Ed had suffered greatly with arthritis for many years and was living at his daughter's home in Sudbury, Mass. He was born in Newton, Mass., March 28, 1888, and prepared for college at Newton High School. He spent two years with us and transferred to M.I.T. He went with the United Shoe Machinery Co., Boston, in 1931. When he retired in 1955, he was Division Head, Sales Department.

"He was a World War I army veteran and held membership in the Eliot Church in Newton, DeCordova Museum in Lincoln, Fine Arts Museum in Worcester, Salisbury Mansion Associates in Worcester and Boston Badminton and Tennis Club. In 1912 Ed married Hilda Johnson in Boston. She died in 1948. Survivors include one son, three daughters, nine grandchildren, one brother and one sister."

I seem to have little but bad news this month. Madeline Besse sent me a clipping from the *New Bedford Standard* that reads as follows: **"Eldred E. Besse,** 83, of 36 Washington St., Fairhaven, died October 13 at St. Luke's Hospital after a brief illness. Born in Fairhaven, he lived all his life there and was a member of the First Congregational Church of Fairhaven. He was past president of the Fairhaven Water Co. Besse was a member of the American Legion, Geo. H. Tabor Lodge A.F. and A.M. and was a graduate of Fairhaven High School and M.I.T. and was a World War I veteran.

"He is survived by his widow; a son, Neil K. Besse of Sao Paulo, Brazil; a brother, Allen Besse of Fairhaven; a sister, Mrs. Peter Nelson of Centerville; two grandchildren and two great-grandchildren."

A letter, now six months old, from **Harry Tisdale** tells of a trip he took last spring to visit a friend in Orlando. Like myself he is living alone in Ft. Meyers Beach and has a cleaning woman to help out. He is still cutting neighbors' lawns.—**Oberlin S. Clark,** Secretary, 50 Leonard Rd., North Weymouth, Mass. 02191

12

We have all just concluded our Christmas and New Year's holidays, and most of us are settling down quietly for the winter with its snow and sleet. The records indicate that there are 47 who are still living in New England, or nearly 40 per cent of the class. There are, however, 13 men whom we know reside or usually winter in Florida, and at least 15 others who live in California or other locations with warmer temperatures, south of Virginia.

We have just discovered that the oldest member of the Class of 1912 is our only coed, **Hattie Dora Frances Haub,** who will be 91 next month on Washington's birthday. This displaces **Charles McCormack** who will be 88 next May. Sorry, Mac. Hattie likes to say that she and *George* were born on the same day, if not the same year. She also enjoys saying that the people who like her call her Hattie, dear friend, and those who don't call her Hattie, darn fool.

In 1899 she entered Stanford University, where she was elected to Phi Beta Kappa, and graduated in 1903 with a B.A. degree, majoring in physiology and histology. She planned to go into medicine but was discouraged by her sister and a doctor who said the life was too hard for a woman. So she decided to teach science in high school. In 1909, her dream of attending M.I.T. was realized, and in 1912 she received her S.B. degree in Course V. She says there were but two women in the Institute at

Hattie D. F. Haub, '12

the time; she was the only one in our class.

Returning to California, she became the science department chairman at Oakland High School. Later she was appointed dean and then vice-principal at Piedmont High School, where she continued until retirement in 1941. She was presented with a California Secondary Life Diploma and a special Credential for School Administration. She wrote frequently for magazines and journals and was the author of a book, *How to Teach Secondary Chemistry*. Dr. Joel H. Hildebrand of the University of California who wrote the foreword, stated, "Miss Haub's students have a superior enthusiasm and grasp of their subjects." She treasures many letters of congratulation and commendation from those under whom she studied.

Hattie was a charter member of the Berkeley Tennis Club and a great hiker, and has travelled throughout this country and Europe. In 1906, she walked across the state with a group, carrying provisions by mule team, to camp at Lake Tahoe.

Hattie never married and some of her old dates might remember that she told them, "Well, it's time to go now. I must study." Since 1968 she has been in a retirement home due to accidents resulting in broken bones. For her age, she has excellent health and reads her newspaper every day. She is able to scoot about her rooms in her wheelchair and tend her plants. Only three years ago, she sneaked out of the home one afternoon to attend a football game nearby. She still has a distinguished appearance, fine features, clear blue eyes and snow white hair. Her wit and humor are still with her. According to her Aunt, Vera Stump, who sent me this information, she may well live to be one hundred. To you, Hattie Haub, "dear friend", the Class of 1912 sends its hearty greetings and very best wishes!

Jonathan Noyes returned home to Texas in October after his usual vacation at the little town of Brooklin on the northern Maine coast. On his return trip, he spent a week in Andover, Mass., with **Cy Springall** and Marjorie. They are both much better and are "as peppy as ever." After a stop in Wisconsin to visit three of his great-grandsons, he went over to Duluth, Minn., where he once lived for 12 years. While there, Jonathan enjoyed a fine visit with **Don Radford** and Kate, from whom I have never received any word previously. He reports they are both in excellent health. He was unable to contact Willis Salisbury, either at Minneapolis or Hungry Jack Lake. He must have been away on an extended trip as usual. Jonathan says, "The important news in the Noyes family is that Lillian, our oldest daughter, was awarded a Ph.D. degree at the University of Texas, in September. The Noyes tribe now 'has a doctor in the house'. Best of greetings to Helen and you."

George Sprowls writes, "I was sorry to hear of the passing of Joe Desloge. I took several canoe trips with him when at Tech and later we rode a river boat from St. Louis to Keokuk to inspect a dam on the Mississippi. He was a wonderful man. I am still active at golf, out every day. I still play with our '65' club. Am still waiting to get official notice of the 60th reunion from our class president. How many do you expect? I surely appreciate your copious news in the *Review* which keeps me up-to-date on the activities of our classmates. Speaking of covered bridges, I saw one on a golf club in Hartville last week. Come out and I will show it to you."

Arch Eicher's wife, Agnes, sent me the notice of the passing of Jack Lenaerts. She also writes, "Arch has been only fairly well of late. I doubt if we shall visit Florida this winter." . . . **Carl Rowley** and Betty spent the fall in their cottage on Cape Cod as usual. . . . **John Selfridge** advises, "My general health is, fortunately, good, though I now have 'wooden' feet and am too heavy. I am still driving but my wife, Virginia, has developed permanent eye trouble, so I spend all of my time with her. Her general health is otherwise good, and she is able to get about. We celebrated our 57th wedding anniversary just recently. We are living in a wonderful new retirement apartment with some 300 fellow residents, all ancient and honorable. We have been here for nearly two years and enjoy it greatly. We take no long trips but occasionally go to San Francisco to shop and to lunch with friends. We also participate in the local activities. I maintain my Bohemian Club membership but rarely use it. We are most fortunate to have two of our families living nearby. Our oldest granddaughter has two children whom we see often. Our in-law grandchildren have five youngsters. We have two grandsons who are married but no children. Another granddaughter is a graduate nurse. Five of the other grandchildren (we have ten) are in school."

Our "old reliable", **Jim Cook**, writes that he had just returned in late September from a visit in Vermont with a retired former business associate. They visited other friends in the vicinity and enjoyed the beautiful Vermont countryside. "More cows than people and many acres of corn." Jim's daughter, Mary, has been recently appointed assistant administrator of a Marblehead hospital. His other daughter, Sue, also married, has just completed five years at a Wolfeboro, N.H. hospital as a registered medical technologist. His grandson, James Harris, after returning from Vietnam, took the apprentice course at General Electric and is now happy with them in the tool work department. He was married in October. Jim says, "I hope to attend our 60th reunion in Cambridge, though it is difficult for a lame and deaf octogenarian who cannot drive." A picture of Jim appeared in the December *Review*.

Walter Lang and **Charles McCormack** both sent me the obituaries of **John Pettingell**'s passing. Walter adds, "I have nothing personal to write at this time. My wife and I are well and living quietly in the same old home watching the rest of the world whiz by." Mac says he took a trip this summer to his native New Brunswick and sent along a photo of the Hartland, N.B. covered bridge, the longest in the world. He says, "My old home was about one-half mile down the river from its west end. It was originally an open bridge of the Howe type, and was built by a neighboring contractor, Albert Brewer. It had seven 180-foot spans and was set on rock-filled cribwork piers. It was financed by local farmers and businessmen of the village, and for many years was operated as a toll bridge. My father was president of the company and also construction inspector. The cost at that time, 1901, was but $27,945."

I was surprised and pleased to receive a visit last week from **Henry Babcock** and his wife Ruth. They were on their way from their summer home in Goshen, Mass., and planned to visit friends near Washington, D.C., before leaving for California. Both are in good health. Henry is still active in consulting and is working on his second book, *Valuation of Investment Property*. They are planning to attend our reunion.

We have learned belatedly of the death of **Ralph Riddell** over a year ago in Lakeland, Fla., from his wife, Augusta. Ralph was in our class for but one year in Course I. He was employed for a number of years with the Burroughs Adding Machine Co. in Burlington, Vt.

All of us have received formal notice of the plans for our 60th reunion from our president, **Albion Davis.** This event, which may be the last of its kind, will be held on campus from Friday, June 2, through Monday, June 5, 1972. We have heard already from 42 men that they plan to attend if health permits, so with perhaps 16 wives, we believe there is a good probability of meeting or exceeding our quota of 40. Be sure to write Albion promptly if you have not already done so. We have a most enthusiastic class which is very gratifying.—**Ray E. Wilson,** Secretary, 304 Park Ave., Swarthmore, Pa. 19081

13

We hope you all had a "Merry Xmas"

and that Santa Claus was good to you. Also, Happy New Year and we hope you will enjoy 1972 in good health and spirits (both kinds).

Phil Burt wrote us a very heartwarming letter: "I understand that May 23 has been proclaimed 'Capen Day', at which time you and your good wife are to be honored by your legion of friends in Canton. As one of your classmates at Canton High in 1909, let me add my congratulations and best wishes too. Your career in Canton has been a long and faithful one to the town and I know that when you leave for your 'retirement home' in Maine, you will be missed. Your hard work over the years has kept 1913 in the forefront as one of the most active classes of the Alumni Association. Your class notes in the *Technology Review* have always been lengthy and informative. Thanks for a good job well done, Phil, and again my best wishes to you and your wife. I hope that you have many happy years in Maine."

We appreciate receiving through the Alumni Fund Office several brief notes. **Henry Glidden** writes: "After seven weeks pursuing my hobby of water color painting under the relaxing warm sun in Florida, am back into the old routine of cutting mats, making frames and entering art exhibitions in the south shore area of Massachusetts. Don't expect to get in to Alumni Day. Driving into a city has become something to be avoided. Give my warmest greetings to 1913ers that are there." . . . **Stanley Parker** writes: "Louise and I are well and living quietly in Palo Alto. We are not doing as much travelling as we used to. Enjoy reading about classmates in class notes. Later Stanley adds: "I'm sorry to say that I've had to miss the '13 class reunions since our tenth at Eastham on the Cape. Afraid I wouldn't recognize my old classmates now. I was interested to hear you were now at Biddeford. I used to spend two or three days a month there for 10 years ('18-'28). **Bill Eichorn** was there part of that time. I have many fine memories of shore dinners at Mrs. Flood's on the 'Pool' road and merry evenings with Bill in Portland."

Paul Rudolph prints: "Hi to Brewster-Capen Combo. Wondering if my classmates are getting into the 80-year-old classification also? Hope they too are going strong." Yes, many of our classmates are 80 years old or will be by early 1972. Many of them are going strong, but not too strong. The notes, letters, and comments are still being received with the dues. . . . **Stanley Hodgman** adds concerning 1973 reunion: "Doubtful health." Buck up, Stan. Come east and enjoy our elixir of Massachusetts. . . . **Walter Muther,** a hardy person, writes, "I survived a hernia and am mending easily, but the trouble on my right arm was much more troublesome. I'm sure I'll live a little longer. See you in '72 if alive." . . . **Frank Achard** adds: "Glad to have your address. I've been having a wild summer. I'll write you when I get a breath." . . . **Geoffrey Rollason** can be depended on showing up at all reunions and he pens: "Am in between cataract operations, so please excuse scrawl. Can't see too good with one eye

Jim Brett, '13 (left) and Bill Mattson, '13, this past summer at the Mattson home in Golden, Colo.

and not at all with the other. Hope you and Roz are going fine. We are not making plans too far ahead, but pretty good considering. Marguerite sends best to you both." . . . **Raymond Haynes** remarks: "Best regards to you and Mrs. Capen."

Hilding Carlson types: "Sorry to be late, but just returned from a summer in Scandinavia. The weather was beautiful and the trip over by ship was the calmest crossing we have ever experienced. Can report that no one on the whole ship missed a single meal. Hope you and Roz are enjoying it in Maine. If we are around next year we'll drop in for a visit. We usually summer in Milton, N.H., just a hop and a skip from you. Best regards." . . . **John Ladd** adds: "I do not expect to attend our 60th reunion; it is rather too far from Florida. You have chosen a nice place to live. I used to go to Kennebunkport, Maine, summers."

William Mattson always comes through with a newsy letter. "Here is my check for my class dues. It is one bill I like to pay as it is the least I can do to show my appreciation for the wonderful job you both have done for the M.I.T. Class of 1913. And speaking of appreciation, let me tell you how your class notes helped me activate a wonderful friendship that had been dormant for many years. **Clarence** (Bunny) **Brett** (now called Jim) was one of my best friends when we were students at M.I.T. We founded a local fraternity that later became the Tech Chapter of Kappa Sigma—still going strong. We met only at class reunions and our business careers were wide apart. In February, 1970, Jo and I were in Mesa, Ariz., on a trip back from Texas. Years ago I remembered reading in your class notes that Mr. and Mrs. Brett had moved from New Jersey to Mesa, and later Mrs. Brett had died. Was Bunny still there when Jo and I arrived? Yes, he was. He had just remarried and we had a splendid reunion. Later that year (November, 1970) on our way to Los Angeles we stopped at their home in Scottsdale where they were then living and enjoyed their hospitality for several days. Then this year they planned an extensive auto trip through the middle west and the west coast and honored us by making our Colorado home one of their first stops. Jim had never been in this area and we took them to Central City (an old mining town). We stayed at a motel on the shore of Grand Lake (a beautiful spot), then over Trail Ridge Road (12,185-feet elevation), a world famous view of the Rockies. Then to Colorado Springs, the Air Force Academy, Garden of the Gods and the Broadmoor Hotel, etc. They were with us for ten days. Wish they could have stayed longer. So Phil, if I had not remembered your class notes, we might not have had these delightful visits with Jim and Garnet Brett. Many thanks for your interesting letter about your transition from Canton to Biddeford, Maine. For years I've known you were one of the leading citizens of Canton. You deserved all the dinners, gifts, and congratulations the town gave you, from the Mass. Governor, and all your many friends. Should my wanderings ever take me to Maine, I shall try to visit you and Roz in your new home. The location looks wonderful—near the ocean—and I wish you both lots of happiness and years of enjoyment. Let us know more about it in your class notes. I assume you will continue as class secretary and treasurer. Nobody can take the place of Phil and Roz Capen."

Charlotte Sage surely upholds and lives up to the principles of "Women's Liberation." She is a great credit to M.I.T., and she writes: "It was good to hear from you, even with a bill, but such a nice little bill. I see you have moved, and I hope it is a happy and contented one for you and Roz. I never did thank you both for looking after me last June. Signing up for '73 is a delightfully optimistic deed. If transportation is provided, I really don't care where the great event takes place. My youngest family is back from Africa—settling in Worcester. If you come to Boston, let me know. Good luck and love to both." . . . **George Bakeman** always sends us regularly a few bits of personal news: "Greetings from the Oaks. Hope all goes likewise well with you in Biddeford. Mollie and I just got back from visits with two of our daughter's families in Michigan and Wisconsin. Had hoped to get up to New England this summer, but various complications got in the way. Really must make a real effort again next year as my mouth waters for some fresh Maine lobster." . . . **Howard Currier** states he will attend the 60th reunion with his charming wife. There will be transportation furnished even if we have to charter a bus. . . . It is always a pleasure to hear from **John Farwell** and he writes: "Congratulations on your new address in Maine. I used to be in that area as a kid. Reunion June 1973—I hope to be there if still percolating as at present. Right now never felt better. I vote for the Cape as always. Nothing new with me hereabouts. Same routine, mowing fields, buildings maintenance, etc. Haven't done any traveling, but might take a trip to Europe soon to see how they have been doing in my absence. With my very best."

It is with a heavy heart that we must announce the passing of Edith (Robinson) Horner, **Halsey Horner**'s widow. She died in Wellesley, Mass., October 16, 1971. We shall offer to her survivors the con-

dolences of all of the members of the Class of 1913. . . . Keep your notes and letters as well as comments coming for Roz and Phil. We enjoy reading of your activities.—**George Philip Capen,** Secretary and Treasurer; **Rosalind R. Capen,** Assistant Secretary, Granite Point Road, Biddeford, Maine 04005

14

Ray Dinsmore wrote in late October from Akron in response to my appeal for news and reported on his activities since Alumni Homecoming Day last June. "When I returned from Boston it was my intention to go to my cottage in Winter Harbor, Maine, as soon as possible because the caretaker we had had for years had died and there was uncertainty about his replacement. Also, neither I nor my dog like to travel in very warm weather. There is some country acreage here which has to be mowed at least twice a season to keep it in shape and this requires some skill and knowledge of the contour of the ground and ability to dodge trees and other obstructions with a Farmall Cub, so my spare time for nearly a week was spent on this job. Finally, I was able to set a date for going to Winter Harbor. In the last two or three years I have been fortunate enough to get a reliable young man to drive me back and forth, and this time I made the trip, part of the time in one of the worst thunder storms I have experienced. There, I found a number of repairs to be made inside and out and also that the prospective caretaker could not begin work until the end of the summer season, so I spent much more time than I would have wished trimming bushes, looking after my wife's flower garden and doing housework. This, because it was impractical to try to get anyone to do these limited, but to me disagreeable, tasks for me. Violet who cannot tolerate damp and foggy weather because of rheumatism, awaited my word that the weather had become warm and dry. This did not happen before I had to go home in early September. Once again the mowing and arranging for replacement of some old water pipes, which in turn entailed a considerable amount of cement work and tearing up of the lawn around the cottage. This month we sandwiched in a two-day stay in Cleveland at the A.C.S. Rubber Division International Meeting and a dinner of the Akron Council of Engineering and Scientific Societies where Pete Conrad, the astronaut on the second moon landing spoke. I had a chance to spend five minutes of very interesting conversation with him on the benefits of continuing space exploration."

Ray also sent a column about **Walter Keith** from the *Akron Beacon Journal* of October 17, 1971. After telling of Walt's birth in Oconto, Wisc., his boyhood, and his study of chemical engineering at M.I.T., the article continues, "The timing of his graduation in 1914 was significant, because it coincided with the greatest years of the rubber boom in Akron. Keith started in Goodyear's experimental department, the forerunner of what is now called research and development. First, the new men had to take an eight-week factory course, Keith remembers. 'We learned about all the operations in the plant from washing rubber to tire building.' Speaking of the years of expansion that came after the outbreak of war in Europe, Keith said, 'It was really a beehive in those days.' And what was true for Goodyear was also true for Akron. 'I thought this was the dirtiest town in the world.' Keith was talking about the soot that covered everything, coming from the soft coal that was burned not only by the factories but by every home in the city. Into this sooty but exuberant atmosphere Keith in 1918 brought a bride from Wisconsin, Fama Noyes. There was also a war-related trip to England to learn the British method of treating fabric used in airship and balloon manufacture. 'Because of the submarine danger, we traveled in a convoy and it took us 29 days to zig-zag across the Atlantic,' Keith recalls. The method of travel may have been tedious, but the experience only whetted Keith's taste for travel. In later years he and Mrs. Keith would take many trips abroad which combined sightseeing with business as he developed export sales for his own firm.

Keith's company, the Hygienic Dental Manufacturing Co., had its beginnings some years after Keith switched from Goodyear to Seiberling at the time Seiberling was formed. 'I always had an ambition to go into business for myself,' Keith said, as he related his discovery of a small rubber firm in Michigan that was for sale. For 'a small sum of money' Keith bought the name Hygienic and the firm's supply of materials used in making rubber dentistry equipment. For some time Keith conducted his business from his home, developing a market while having his products processed at the Seiberling plant. Eventually he was able to buy his own machines and move into an office and build a new plant. Since then the plant has been expanded several times and employs over 80 people. There are about 50 products sold mainly to dental equipment manufacturers.

Keith's son Walter, Jr. (M.I.T. '41) has become president and is 'calling all the shots.' But Walter Sr. counts his recent retirement as a mere formality as far as activity goes. He is a former vestryman for Our Saviour Episcopal Church and board member of the Salvation Army in charge of the Christmas campaign ('They made me an honorary colonel,' he said with a modest smile.) One dream he took up at a low stage and can now see it as a thriving part of the community is Akron Art Institute. He was persuaded to join its board when in the early '40s its membership had declined to a lonely twosome. The long rebuilding began and he became the Institute's president for 14 years. His consuming hobby is photography which tied in nicely for added satisfaction with his world travels. The Keiths' latest trip was to Africa.

Home for Mr. and Mrs. Keith is 516 Delaware Ave. The home, the business, and the city must seem a great distance from the sooty surrounding of the past." Ray adds that the article, "doesn't do justice to Walter's skill as a photographer. I have seen several of his travel pictures and in my opinion they would do credit to any pro."

Raymond MacCart divides his time between an apartment in Washington, D.C., and one in Pompano Beach, Fla. Writing of the trip between his two residences, Ray says, "Driving 60-75 m.p.h. for three days has become quite a chore and I figured I should quit it while I was ahead. The trouble is that I may change my mind when the time comes to go again but I doubt I will, particularly since driving any distance, to me, is a very boring experience. I have nothing of interest to report as fortunately nothing unusual has occurred to upset the routine which is my way of life." . . . **Fred Hurlbutt** wrote in October, from his home in Winnetka, Ill., that the state of his health has limited his activities. He's able, however, to play a bit of bridge at his club, and to golf three days a week in a cart. . . . **Skip Dawson** wrote in the fall, from his home in Pittsfield, that in July, 1970, he "suffered a nearly fatal automobile accident. I was unconscious for four days and only survived due to the great skills of a team of four surgeons and the ultra-modern facilities of our hospital—recovery is now almost complete." . . . **Bob Townend** wrote me last October, "Recently our two daughters joined us for a few days' trip through lower Vermont, New Hampshire and northern Massachusetts to see the autumn foliage and to visit my old stamping ground. If you do not mind a suggestion, I wondered if you could not canvass members of our class regarding what they have been doing since graduation, also perhaps information regarding their present hobbies or interests." I gladly adopt Bob's suggestion and pass it along as an appeal to everyone in the class. Whatever you can tell me will be most welcome; please include some information on marriage, children, grandchildren and, for special honorable mention, great-grandchildren.

And lastly, Ray Dinsmore, as president of our class, wrote me on October 25, "Conforming with the recommendation of the Executive Committee and my own strong agreement, this is official notification that you are appointed Class Secretary until such time as officers are again voted for at the next class reunion."

Corrected address: R. P. Dinsmore, 795 Merriman Road, Akron, Ohio 44303; New address: Arthur W. Johnson, 400 N.E. 20th St., Apt. 105C, Boca Raton, Fla. 33432.—**Charles H. Chatfield,** Secretary, 177 Steele Rd., West Hartford, Conn. 06119

15

The Class Supreme supremes again! Blessed with a warm, bright, sunny day, our first class luncheon on October 15 at the Faculty Club was a tremendous success. No night driving, so 21 of us appeared at noon for cocktails and then lunch. The old Pirate in his swashbuckling form led us with his rousing "we are happy". You will see that the long distance men came out strong: Whit Brown,

Class of 1916 members at their 55th reunion in June, 1971, at Chatham Bars, Cape Cod: left, Frances Duff, Phil Baker, Emory Kemp and Paul Duff; center,

Ralph and Sibyl Fletcher and Len Stone; right, Rose and Bob O'Brien, Honorary Member of the Class of 1916 and 1916's Reunion Chairman.

Concord, Mass.; Larry Bailey, Bill Brackett and Ray Delano all from South Duxbury; Evers Burtner, Kingston, N.H.; Jack Dalton and Pop Wood, Peterboro, N.H.; Fred Waters, Marblehead; Max Woythaler, Framingham, and the winnah—Ben Neal, Lockport, N.Y. What loyalty these fellows have. In addition present were Dinger Doane, Herb Eisenberg, David Hamburg, Clive Lacy, Horatio Lamson, Azel Mack, Archie Morrison, Harry Murphy, The Pirate, Gerry Rooney and Wally Pike. A fine group of old friends and classmates. Then, on the night before, Hank Marion called from Oklahoma City to send his regards to all. Wonderful! It's impressive that many who could not come had interest and feeling enough to send regrets and regards: Jerry Coldwell (Vermont); Wayne Bradley (N.H.); Henry Daley; Larry Landers (in the hospital and we sent him a note signed by us all); John Dalton (Providence); Speed Williams; Sol Schneider (Bermuda); Jim Tobey, Larry Quirk (South America); Frank Parsons (Florida); Charlie Norton, Frank Murphy (Florida); Boots Malone; Joe Livermore. This noon-time meeting, eliminating night driving, was an outstanding success and we've agreed to have the future meetings at this time (except, of course on Alumni Day).

Shortly after the class luncheon, I had a card from **Larry Quirk** in Buenos Aires: "I flew in here from Santiago, Chile, after two weeks on the west coast of South America. My next stop will be Sao Paulo, Brazil and then home on October 26." Sounds like an exciting and strenuous trip for Larry. . . . Whit Brown, Jack Dalton, Clive Lacy and Max Woythaler attended the inauguration of President Wiesner at M.I.T. on October 5. . . . **Alton Cook** writes: "I note there is to be a '15 luncheon in October but won't be able to make it. Perhaps there will be a 'gathering' of '15ers in the spring of '72! For all practical purposes, I am now retired but go in about once a week to give my *moral* as well as technical support. Give my best regards to all them '15ers who show at the luncheon."

At the Fiftieth Convention of the American Association of Textile Chemists and Colorists in Boston in October, I spent some pleasant time with **John Dalton,** who was honored as one of the charter members of the association. Formerly technical director of the famous Pacific Mills in Lawrence, Mass., John made a number of valuable contributions to the woolen and worsted industry. . . . **Pop Wood** was in a Canadian-American Lawn Bowling tournament at the Spalding Inn Club, Whitefield, N.H. Rather strenuous at his age. . . . **Louie Young** injured his back in a fall, but I'm glad to report he is getting better. Hurry up Louie and get well. So: how's that for this month?—**Azel W. Mack,** Class Secretary, 100 Memorial Drive, Cambridge, Mass. 02142

16

Now we'll start off the New Year, a Happy New Year, with the hope that our allotted space can take all the news we are receiving from our good old reliable correspondents.

Dina Coleman wrote early in September from Lexington, Ky., "After worrying with unions for two years, I gave up and closed the brick plant, new kiln and all—saves on aspirin." He says the plant has been leased to another group—"young and tough"—so he has hopes for success. In the meantime, Transylvania College, the Philharmonic and the Cerebral Palsy activities have appropriated the time thus released. He says: "It is amazing how many things these do-gooders can dream up for someone else to do—sometimes it interferes with bridge at the venerable Lexington Club." . . . Gyps and **Cy Guething** say there was less than normal rain last summer; however, their "good old gardener" kept the garden watered while they were away in Boothbay Harbor so that early in September, Cy speaks of reaping the harvest of tomatoes and pole beans—50 poles, planted 10 at a time—"plenty of beans for the neighbors." . . . **Coke Flannagan** writes from Inverness, Fla., that his wife Alma is having her 50th reunion, Florida State University, in October in Tallahassee, not too far away. So they plan to take in the festivities and Coke expects she will be on "cloud nine" for several days. Then followed one of Coke's stories, the kind that can be repeated for years but are not candidates for the 1916 column.

Virginia and **Joel Connolly** were delightful surprise visitors at your secretary's home in Mountain Lakes early in October on their way from Tucson to their summer home in Brewster, Mass. Joel tells a little-known bit of history about the Bucentaur crossing the Charles River in June 1916. Apparently it was not expected that many of the faculty would take the boat ride, so a chorus of students, of which he was one, was formed and rehearsed to sing on the boat while crossing. However so many of the faculty did show up there was no room for the chorus. Hence the chorus sang on the boat at the Boston side, then jumped on the street cars to cross the bridge, and sang again on the Cambridge side as the Bucentaur arrived!

We regret to report the death of **Norman J. Thompson** on September 25 at his home in Westwood. As mentioned in the *Boston Globe,* "He was responsible for the design and development of the automatic spray sprinkler and was one of the country's leading figures in fire-control devices. In addition to the automatic fire sprinkler, Mr. Thompson held the patents to several other processes relating to fire control. After he retired from the Factory Mutuals System in 1959, he published a well-known book *Fire Behavior and Sprinklers,* widely used as an engineering guide and as a handbook for fire protection." He started with Factory Mutual in 1924, worked first as a research engineer, and later as director of the Factory Mutual Laboratories. In 1957 he received the Distinguished Service Scroll of the American Fire Protection Association. We will miss him.

We are always glad to have the action comments of **Dave Patten.** In his October letter he mentioned that a recent activity of his other than lawn mowing was "to attend the first fall meeting of the M.I.T. Boston Club luncheon, with Dr. Draper speaking, with the assistance of Doc Lewis. Few if any local '16ers attend these winter monthly affairs so I usually sit with the Class of '15. I did go to the inauguration of our new President, Jerry Wiesner—luncheon, afternoon festivities, and a buffet dinner to climax an interesting and well-managed M.I.T. milestone. We ran into **Walt Binger** and **Hy Ullian** and his wife at the inauguration. Walt flew over from New York and looked very fit, having spent, so he said, a couple of hours in the saddle that

morning. The luncheon was accompanied with the announcement that there would be no speakers. However, none other than Senator Ted Kennedy had to get up and remind the assembled alumni and guests that it was his distinguished brother the President who selected Wiesner as his science director."

Nat Warshaw continues actively in his chosen field with an article: "An Engineer Looks at Pallet Storage Racks," published in the June-July issue of *Today's Transport.* In a subheading we read, "Development of modern warehouse system has not diminished the role of the rack. On the contrary, it is integral to most storage design. The author examines in detail current innovation in rack construction." . . . **Ed Hanford** of Hammond, Ind., calls the reunion picture "a real snappy photo of a pretty sharp group." His daughter just graduated from Indiana University, is getting married at the end of October, and will be an art teacher in the Hammond schools after November 15. . . . **Dick Berger** has a new letterhead, "Cancer Prevention, Inc." Bridgeport, Conn. In a recent letter he wrote: "Although I have no printed literature at hand at the present to substantiate the fact, it is generally recognized in scientific circles that all tars resulting from incomplete combustion are 'carcinogenic'—that is, cancer-causing to some extent—and therefore should be contacted or taken into the human system with moderation and caution if possible."

Theron Curtis of Barrington, R.I., says his two sons and their families "are now near us on the Cape so we manage a semi-Disneyland most of the time." Off to Clearwater Beach, Fla., for four or five weeks in January and February is now their expectation. As for philosophy, Theron says, "Who knows what will happen next? We all live in hope and I'm lucky I have a gal named Hope to live with!"

Another honor, the highest one yet, has come to your Secretary **Harold Dodge** (reported by his humble assistant for reasons that are no doubt obvious). Harold has been selected as the 1971 Samuel S. Wilks Memorial Medalist by the American Statistical Association. The presentation was made at the 17th Army Design of Experiments Conference in Washington, D.C., on the evening of October 27, 1971. His acceptance speech was read by General Leslie Simon of Army Ordnance, as the effort and excitement attending his personal appearance was deemed unwise by his doctor. (However, Harold prepared the preceding notes for this issue so he is really on the mend.) The following is from a letter informing Harold of his latest honor (snitched by ye scribe), "The American Statistical Association, in cooperation with the Army, established the Samuel S. Wilks Memorial Medal in 1964 to honor the memory of Samuel S. Wilks and the extensive contributions he made toward the application of mathematical statistics to problems related not only to those of the Army, but to the U.S. Government and to the country as well. It is our desire to recognize more formally the multitude of significant contributions you have made to the field of statistics in general, the design and analysis of sampling inspection plans and criteria, including chain sampling, your numerous contributions to A.S.O.C. and A.S.T.M., the teaching and promotion of statistics, and the leadership you have shown over the years by presenting you the 1971 Wilks Memorial Medal."

Do write us often, even if only a little, to keep the pipeline filled.—**Harold F. Dodge,** Secretary, 96 Briarcliff Rd., Mountain Lakes, N.J. 07046; **Leonard Stone,** Assistant Secretary, 34-16 85th St., Jackson Heights, N.Y. 11372

17

Acting on the Northfield-made decision to have our 55th Reunion on Monday, Tuesday and Wednesday, Tubby Strout reports that arrangements on that basis are well in hand. He recently saw the management at Chatham Bars Inn and all Tubby now wants are your suggestions of what you would like to have and, most importantly, your presence June 5, 6 and 7. Some detailed information is being prepared.

The Lunns and the Dunnings were pleased to be guests of the Class of 1918 at its one-day reunion held in October at Endicott House. Please read the adjoining 1918 notes and learn of this very pleasant affair.

Two "regulars" were absent at Northfield, **Ray Maeder** and **Miles Demond** and were missed. They have reported temporary illnesses as the reason. A good letter from **Ray Brooks** indicates progress in his recuperation and expresses his thanks and appreciation for the thoughts and expressions from many of the Class. He mentions particularly the many-signatured card via Northfield. Another "regular," **Clarence Seely,** had to cancel because of work interference.

Each year the Alumni Association recognizes outstanding performances of alumni by issuing citations. This year the recipient of a Presidential Citation is **Tom Meloy** for his service on the Washington, D.C. Alumni Fund Area Council.

In addition to the news mentioned in the October/November notes that had come **Joe Littlefield**'s way there is more. While maneuvering a boat onto its trailer he pulled a shoulder muscle resulting in his arm being put in a sling. This didn't help his commuting to a special three-day-a-week job for the Southeast Banking Corp., in Miami.

The Florida migration has started: **George Duryea** to Lake Wales, **Larry Gardner** to New Smyrna Beach, **Ken Lane** to Miami, **Ray Stevens** to Naples and **John Holton** to Casey Key. . . . Acknowledgement is made to the following who by letter or card have expressed best wishes, remembrances and in many cases intentions to attend our 55th; Adams, Abele, Abels, Batschy, Carter, Clayton, Chisholm, Collins, Crane, Curtin, Dickson, Gillespie, Hall, Holt, Kenigsberg, Krug, Ben Lewis, Joslin, Moody, Panettiere, Payne, Pond, Rogers, Sterner, Turner, Bill Tuttle, Venable, Waite, Wells, and Whitney.

Dick Loengard also had to miss the reunion but he held forth at the monthly October luncheon with 1916 at the Chemists' Club, New York on the 14th. He, Ed Aldrin, Neuberg and Seely outnumbered the '16ers. These lunches are scheduled for the Thursday of the first full week of a month. If you are in town you will be welcome. New word from Dick says that only he and Seely got to the November lunch. The big M.I.T. get-together at the Metropolitan Museum of Art made for a good evening but Dick did not see any other '17ers there.—**Stanley C. Dunning,** Secretary, 6 Jason St., Arlington, Mass. 02174; **Richard O. Loengard,** Assistant Secretary, 21 East 87th St., New York, N. Y. 10028

18

October 17 was a glorious autumn day with the fall foliage at its best and warm, late summer sunshine at the lovely grounds of Endicott House, for the second mini-reunion of 1918. We were particularly fortunate to have President Jerome Wiesner as our speaker, who was made an honorary member of our Class of 1918, with a suitably inscribed scroll. His talk was most interesting and informal, followed by a question and answer period. Among his observations: (a) Today's students are more seriously concerned about their future and careers offering financial security after graduation. (b) Most students no longer support the small radical minority whereas two and three years ago, they were sympathetic to them. (c) The curriculum is flexible and offers many options but hard work and serious study are still needed to get a degree. (d) Student and faculty participation are encouraged on problems common to all but final decisions are heavily weighted by the experience of the administration. We felt reassured that M.I.T. affairs are in extremely capable hands. In addition to members of our class, our guests included the Ken Brocks and the Panos Spiliakoses of the Alumni Office. We were also happy to greet the Al Lunns and Stan Dunnings of the Class of 1917, and the Paul Sheelines and Ben Bristols of the Class of 1919. It is our hope that in succeeding years this mini-reunion will be expanded to include all members of these three classes.

The following '18ers were present: Julie Avery, John Markham, Sam Chamberlain, John Kilduff, Herb McNary, Al Grossman, Clarence Fuller, Charlie Watt, Len Levine, John Kiley, Eli Berman, Ted Braaten, Pete Harrall, Tom Brosnahan, Max Seltzer, with their wives, and Sax Fletcher, Charlie Tavener, Julie Howe, and Jorge Pena Polo. Again the prize for coming the greatest distance goes to the Harralls from Maryland. As I think back to this delightful afternoon—relaxing, sociable and informative—I take great pride in being part of this group. Looking back over 50 years, I see them as youngsters—eager beavers working hard to make something of themselves. Now they are the finished product and I like the way they deport themselves. They get up on their feet and express themselves asking searching questions

Class of 1918 at their "mini-reunion" on October 17, 1971 at the Endicott House. (Photo courtesy of Samuel V. Chamberlain, '18)

and in turn answer them. They are solid citizens doing their part in their own and in many ways in their respective communities. Yes, I like these men and the gracious and lovely ladies who have been their companions these many years. A number of you wrote from more distant points expressing regrets at being unable to be with us on October 17. **Frank Wells** just finished a bout in the hospital. We hope he is now completely recovered. Among others was a newsy letter from **Ned Longly** and a card from **Granny Smith** from Sarasota, Fla. He just returned from six weeks in Europe and is currently vice president of the local M.I.T. club. He asks all '18ers to call him at 813-924-5076 when travelling in this region.

An article appeared in the *Boston Herald* of November 7, describing the "Flying Cloud." The principal illustration was a drawing from a study of early prints, records and models of the ship by **F. Alexander Magoun.**

In the previous issue of the *Review* we reported the death of **Clarence Hanscom.** Thanks to Charlie Tavener, who lived three doors away from him until graduation, we include the following review of his career.

"Clarence Dean Hanscom of Bedminster, N.J., died May 4 at his home in Cuernavaca, Mexico, at the age of 76. He and his wife were proprietors of a successful antique business visited on occasion by art experts and at the time of his death he was at work writing a book on early American glass.

"Retired in 1960, Mr. Hanscom was employed for 36 years with Bell Telephone Laboratories in New York, first in power and telephone equipment design and later in publication of technical articles, books and lecture aids. He is credited with several patents in telephone switching and signalling.

"Possibly the experiences he best liked to relate, however, came early in his career. After graduating from Harvard College in 1917, he became an assistant wind tunnel chief at M.I.T., from which job he was hired by the Glenn L. Martin Co. airplane builders, where he designed for World War I flying ace General Billy Mitchell, a bomber to be used against navy ships. Several months later the plane, whose particular design was needed to carry the then unusual weight of a ton of bombs, was used successfully in various bombing attacks on several battleships. Navy admirals however, were against the experiment and denied the effect of bombing and the argument resulted in Mitchell's court martial. Mr. Hanscom used to say that the issue was never really settled until World War II proved Mitchell was right, and added that there were a lot of things about the tests that never came to light. After this Hanscom tried to organize an air express between New York and Chicago with the cooperation of the American Express Co., but he said, 'We couldn't get the venture going. Flying was a little too unpopular in those days. Lindbergh hadn't yet flown the Atlantic.' " Hanscom is survived by his wife Mrs. Marcellite Hanscom.

We sorrowfully record the death of **Norman H. Hamilton** of Williamsburg, Va. . . . Walter Biggar can be reached at P.O. Box 1225, Jensen Beach, Fla. 33457.—**Max Seltzer,** Secretary, 60 Longwood Ave., Brookline, Mass. 02146; **Leonard I. Levine,** 519 Washington St., Brookline, Mass. 02146

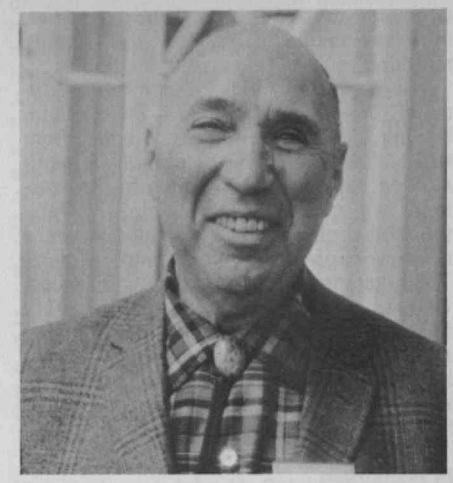
20

It is with profound sorrow that I must announce the death, on October 28, of one of our most admired and beloved classmates, **Homer Howes** of 35 Lake Forest, St. Louis. Homer, stricken with polio when an undergraduate and unable to get around without extreme effort, surmounted all obstacles and made an outstanding success both in business and in his personal life. He became vice president and director of Bemis Brothers Bag Co., served as president of the Textile Bag Manufacturers Association and as a trustee of Fisk University. Despite his handicap, he traveled extensively with his charming and devoted wife, Vera, whom many of you will remember from their happy visit to the 50th Reunion. Vera writes of their mutual enjoyment of that great occasion and mentions Homer's deep and abiding interest in the Institute. The Class suffers a grievous loss at the passing of this distinguished and courageous classmate. He has been a constant source of inspiration for us all.

Through the courtesy of George Bond, '19, I am able to report the death of **Ki Kee Chun** who passed away nearly a year ago. Ki had been living in Los Angeles. His wife's death preceded his by about one year. Ki will be remembered by all who knew him as one of the friendliest and most lovable of characters. I retain a vivid memory of his infectious good humor and warmly affectionate nature. I had tried for years to locate and get in touch with him but to no avail. He had been a classmate of George Bond at Tech High School in Springfield, Mass., which accounts for George's thoughtful note.

Gladys and **Foster Doane** continue in their constructive and glamorous travels. They have recently returned to their home in Neenah, Wis., from a lengthy stay in Europe. They started at Vienna where Foster was a panel member at the meeting of the United Nations Industrial Development Organization concerning the promotion of the pulp and paper industry in developing nations. As many of you know, Foster is a world renowned authority on the subject. The Doanes then visited Torremolinos, Spain, for a meeting on the use of bagasse as a material for pulp and paper. They then visited Mallorca, Milan, Lugano and Zurich, then on to Prague and Bratislava where Foster was the guest of Czech Pulp and Paper Research Institute. They wound up attending a meeting of the European Pulp and Paper Association in Budapest, stopping on the way home at Brussels.

Two of our classmates, formerly both prominently associated with the U.S. Navy, are Rear Admiral **Donald Royce** of Meadow Rd., Riverside, Conn., and Commander **Melville Powers** who lives in Whispering Waters Apartments, Winter Park, Fla. . . . **Whitney Swift,** who taught mathematics at Groton School, is in Andover, Mass., at 50B, Washington Park Dr. . . . We remember trying unsuccessfully to get in touch with **Sam Schenburg** who distinguished himself as director of science for the New York City Board of Education. The Alumni Office now assures me that Sam is at Oceanside Plaza, 5555 Collins Ave., Miami Beach. Say 'hello' to Morris Lipp for us, Sam.—**Harold Bugbee,** 21 Everell Rd., Winchester, Mass. 01890



Carole A. Clarke, '21

21

Happy New Year! With 1971 a time of the past, its wonderful 50th Reunion still a fond memory, but its sadness occasioned by the loss of our Class President and other classmates, we enter a new year. May it treat you kindly!

Salute

Carole A. Clarke, our Secretary-Treasurer for the past 25 years, announced his retirement from those duties in signing off in the December class notes. He had reluctantly agreed to another five-year term when approached by the nominating committee last May, feeling that with Ray St. Laurent accepting another term as President, he too should continue his close relationships with Ray and the Class. Cac well deserves relief from these duties after 50 years of meeting deadlines for class notes. His record and interesting columns were unsurpassed. He was awarded the Bronze Beaver in 1955 by the Alumni Association, and the Outstanding Alumnus Award from the M.I.T. Club of Northern New Jersey in 1966. Speaking of beavers he also was awarded a Silver Beaver from the Eagle Rock Council, Boy Scouts of America in 1956. Cac, we salute you and we thank you!

Your new Secretary also feels that a salute is in order at this time to Maxine Clarke. A professional artist and art teacher, she has had a number of one-man shows of her paintings. Currently a number of her paintings of Mexican scenes adorn the walls of the Brielle Public Library. They are delightful.

Changing of the Guard

With the death of our Class President and resignation of our Secretary-Treasurer, a new line-up of class officers has evolved: President, **Irving D. Jakobson;** Vice President, **Edwin T. Steffian;** Secretary, **Sumner Hayward;** Treasurer, **A. Royal Wood.** As back-stop for Ray St. Laurent, Irv Jakobson took over his duties and responsibilities in September and one of these early duties was to provide a back-stop for himself and to fill the other officer vacancies.

Ted Steffian will continue as co-chairman of our 55th Reunion. He is still working as president of Steffian, Steffian and Bradley, Architects. This firm is involved in a number of changes in the Boston skyline as pointed out to your Secretary one day last June from atop McCormick Hall. Incidentally, Ted's son John was promoted to Associate Professor in the School of Architecture effective July 1, 1971. Our congratulations! . . . Roy Wood will be recognized as the treasurer of our 50th Reunion. He is the retired vice president and secretary of the United Illuminating Co., New Haven, Conn., and a C.P.A. employed at one time by Lybrand, Ross Brothers and Montgomery, Public Accountants, Boston.

Fellow Travelers

Cac has turned over notes and numerous letters accumulated over the past summer for use in this column. Traveling has been a major activity in this class and bids fair to continue. Three classmates and wives went to Alaska: the **Wallace Adams**es, the **Albert Genaske**s and the **Dugald Jackson**s. A card from Wally showed a number of musk oxen being raised by the University of Alaska as a wool-raising project, hopefully for use in a new economy in Arctic coastal villages. Al Genaske left on an A.A.R.P. tour just as our reunion was starting and so missed reunion. He wrote a most interesting diary of their tour for which classmates might want to write if contemplating an Alaskan trip. Highlights: the cruise from Victoria to Ketchikan, Juneau and Skagway; fjords, icebergs, the Sourdough Restaurant, Gold Rush Cemetery; his dancing in Indian ceremonial dances; panning for gold—Al got five cents worth after panning half an hour. . . . Dug Jackson writing on August 19 from Seattle before starting their trip, gave his itinerary, which covered most of the places visited by the Genaskes. One big difference was that the Jacksons went by motor coach from Seattle to Fairbanks. Tell us more, Dug, now that your trip is over.

Dorothy and **Joseph Wenick** left for Russia just three days after reunion to visit their son Martin who is political aide to the American ambassador in Moscow. The Wenicks had a two-room suite in the Ambassador's residence where Martin also has his bachelor's quarters. Joe told of the great love of the Russian people for music, ballet and the circus. The Wenicks saw the Bolshoi Ballet in the huge new Palace of the Congresses that seats 6,000. They also attended the circus in the new 2,000-seat circus building. Joe says "the circus performs every night in the year to a full house." Joe was impressed by the tremendous amount of new construction in Moscow—huge cranes everywhere and 25-story apartment houses a block long. Back home, Joe attended the funeral of Chancellor Paul Gray's father in Livingston, N.J., on October 21. He represented the M.I.T. Club of Northern New Jersey and the Class of 1921. Our sympathy is extended to Dr. Gray.

A card dated August 1, 1971 from San Luis Obispo, Calif., told of those intrepid travelers, Madeline and **Ralph Shaw** sojourning in Colorado and California and heading for Hawaii. Madeline was a lifesaver at our reunion when during a long delay at one dinner she sat down at the piano and went through a dazzling repertoire of old-time favorites, to the accompaniment of various off-key male songbirds. . . . **Saul Silverstein** took off for his Safari, number 32, on September 6, 1971 to visit 19 cities and just about every country in South America. He hoped to visit with classmates along the way during his 48-day journey. . . . A note from **Augustus B. Kinzel** reported that he was a principal speaker at the meeting on "Future Trends, Biomedical and Physical" of the International Science Foundation in Crete in August. . . . Eddie and **George Gokey** took a "quickie" vacation in Mallorca, Spain in late September and says it is a gloriously relaxing place to stay. "Now many fall chores await me," he says.

Graciela and **Helier Rodriguez** of Tampa, Fla., went to Cape Cod right after reunion and spent three days with the **Robert F. Millers** at West Chatham. While there, Helier was a guest at the Orleans Coffee Club and was invited to discuss "Cuba Today." Bob Miller reports "This fine informative talk was well-received." Other club members are George Chutter and Donald B. McGuire. Leaving Cape Cod the Rodriguez' drove to Montreal where they met the **Viviano Valdes'** of Mexico City and then continued on to Ottawa and Toronto as a foursome. . . . On their return Helier and

Graciela stopped to see **Robert S. Cook** in Canandaigua, N.Y. Bob was unable to attend reunion because of his health.

Your Secretary took a somewhat unusual three-week jaunt to Switzerland, leaving July 15 with ten friends from New Jersey and Ohio. Primarily a high-altitude hiking trip in southern Switzerland, we gloried in the alpine flowers, the well-kept trails and continuous vistas of snow-capped mountains and glaciers. Total distance hiked was about 100 miles. Can any classmates top this in 1971? Lest anyone get the wrong idea, it must be said that hiking was slow-paced and involved no real mountain climbing. Chair lifts or cog railways took us to the higher altitudes.

In Memoriam

Sadly we record the loss of three of our classmates and extend the sympathy of the class to their survivors. . . . **Raymond C. Fisher,** 5109 N.E. Latimer Place, Seattle, Wash. 98105, died on August 13, 1971. Born in Tacoma, Wash., in 1899, he attended University of Washington and transferred to M.I.T. in his junior year. He earned his master's in Course VI-A. During World War II he was a researcher for the navy in underwater acoustics in San Diego. He retired in 1958 from Boeing Co., where he was employed as an engineer. He leaves his wife, Margery, a brother L. Donald Fisher and a stepson, Donn Charnley. We are indebted to Dugald Jackson for this information. . . . **Carl W. Hammond,** 1107 Mariposa Dr., Vallejo, Calif., 94590, died after a long illness from cancer on September 1, 1971. Carl had been warned by his doctor against attending our 50th Reunion but he was determined to come and he did. Resplendent in red jacket, he attended the various reunion gatherings. Carl and his wife, Henrietta, added greatly to the festivities. Carl was born in Boston in 1898, attended Quincy High School, and graduated in Course II from M.I.T. as an undergraduate, he was a member of Lambda Chi Alpha, the Mechanical Engineering Society and Masque. He retired in 1968 as safety engineer for the Mare Island Naval Shipyard. Previous business associations were with Worthington Pump, Bethlehem Shipbuilding, Travelers Insurance and Lockheed Aircraft. He leaves his wife, two daughters and four grandchildren. . . . **Henri P. Junod,** 17600 S. Woodland Rd., Shaker Heights, Ohio 44120, died on October 6, 1971. He had planned to fly to Boston to attend President Wiesner's inauguration the next day. Harry was born in New York City in 1900, attended Salisbury School in Connecticut and got his S.B. in Course IX-B. A track man at M.I.T., he once tied the world's record for the indoor 60-yard-dash. He was Class Secretary in our senior year, and worked on the *Tech* and *Technique.* During World War I he joined the Royal Flying Corps of Canada and became a lieutenant. He started work for Pickands Mather and Co., in Cleveland in 1923 and at retirement in 1965 was vice chairman of the board and chairman of the executive committee. Harry was active in many community and civic affairs and was a member of the Corporation Development Committee at M.I.T. He attended our 50th Reunion and seemed to enjoy it to the full. He leaves his wife Gertrude and his son Henri Jr.

The **Carole Clarkes** report stopping overnight with **Helen St. Laurent,** 47 Gerard St., Manchester, Conn. 06040. **Irv Jakobson** also stopped by to see Helen early in October. Helen hopes that others will stop by, write, or phone 203-643-6056.

Over the years you loyal '21ers have been wonderful in the way you corresponded with and supplied news items to Cac Clarke. Please keep it up with your new Secretary!—**Sumner Hayward,** Secretary, 224 Richards Rd., Ridgewood, N.J. 07450

22

The good news centers about our 50th Reunion in June 1972. You may have read of the tremendous results attained by the Class of '21 equalling our record-breaking 40th Reunion gift. You have read **Parke Appel**'s October letter urging further efforts in the coming months. You will be receiving new plans for the reunion as the weeks roll along. Parke reports the Inauguration of Paul E. Gray as "Festive days at Tech. Katherine and **Dale Spoor** came from Richmond and stayed with us. We joined Louise and **Don Carpenter** at the Ritz-Carlton before attending a musicale at Kresge. We enjoyed a concert which was devoted to all music lovers. We were lovers for most of the numbers but some were too modern for these old folks. Next day a very impressive inauguration took place at which Archibald MacLeish read an original poem which he wrote for the occasion. It was very moving. (See page 13, December *Review.*) We had a nice luncheon, reception and dinner as well. I saw the following classmates at various intervals of the program: Louise and Don Carpenter, Katherine and Dale Spoor, Mary and Oscar Horovitz, Roy Lamson (our current Class of 1922 Professor), Fearing Pratt, Bob Tonon, Ab Johnson, Warren Ferguson, Saul Copellman and Yard Chittick. The Spoors left on a flight to Spain, Portugal and Majorca last Monday to be gone three weeks. They are coming back to see us briefly when they return so that Dale may attend a dinner meeting at the Endicott House on November 2, similar to the New York meeting but with Jerry Wiesner as the speaker. I have invited and expect that Saul Copellman, Dale Spoor, Yard Chittick and Fearing Pratt will attend with me.

"I want to thank you for your prompt reply with the check and questionnaire. I have now heard from about 60 classmates and they have very generously sent in about $850 so far. This will help a great deal in the preliminaries of publicity and commitments that have to be made far in advance. We are going to have a top-drawer affair that will be long remembered by our Class. The Alumni Association fellows estimate that we will have 275 classmates attending with 225 wives. If this proves out it will be the largest Reunion of any Tech Class."

F. J. Roethlisberger retired from the Harvard Business School in 1967 and has since been engaged in writing. He is the Wallace Brett Donham professor of Human Relations, Emeritus. . . . **Lloyd A. Elmer** is enjoying the good life at Summit, N.J. and working at Farleigh Dickinson University. He has decided that his most useful study at M.I.T. was applied mathematics and theory of elasticity by Professor Charles E. Fuller.

Our registrants list of class members at the president's inauguration include Parke D. Appel, Professor Edward L. Bowles, Donald F. Carpenter, Lee W. Carroll, C. Yardley Chittick, Saul J. Copellman, Warren T. Ferguson, Oscar H. Horovitz, Abbott L. Johnson, Ronald G. MacDonald, Theodore T. Miller, Fearing Pratt, Samuel Reynolds, Dale D. Spoor and Robert Tonon. . . . The sympathy of the class is extended to the families of Floyd J. Wilson, Ontario, Calif.; James A. McDonald, Belmont, Mass.; Henry R. Haines, Visalia, Calif.; and Donald R. Goodnow, Leominster, Mass.

The changes of address received this month include David M. Broudy, New York, N.Y.; Herbert C. Ham, Pittsfield, Mass.; Oscar H. Horovitz, Pompano Beach, Fla.; Maxmilian W. Killars, Laguna Hills, Calif.; Seward W. Livermore, Washington, D.C.; James K. Macomber, Centerport, N.Y.; William G. Rapp, Larchmont, N.Y.; Lt. Col. Walter H. Sitz, Chevy Chase, Md.; Charles H. Taylor, Cranston, R.I.; Lee D. Warrender, Naples, Fla. and Lester A. Williams Silver Spring, Md. . . . Winter greetings to you all in your varied summer, winter, sunny or icy locations. Count your blessings until June!—**Whitworth Ferguson,** Secretary, 333 Ellicott St., Buffalo, N.Y. 14203; **Oscar Horovitz,** Assistant Secretary, Pompano Beach, Fla. 33060

23

Your Secretary-Treasurer is now back on the job of writing the Class Notes. We are extremely grateful for Pete's excellent handling of these while we were so jammed up with other post-retirement consulting work. The job was beautifully handled in a manner much more interesting and stimulating. . . . Upon returning from a short vacation in England and Ireland we were shocked to learn of the death of our good friend and loyal classmate **George A. Johnson** who had so little time to be President of our great class of 1923—only seven months—March to October of this year. At this point we do not know how many years he served as Class Agent but there were many. He did so much want to be on hand to present the Class Gift at our 50th.

Edwin H. Schmitz has taken over as President and he has directed me to make a contribution to the Cancer Fund as a suitable memorial to George. . . . **Charles M. Mapes** is now 1st vice president and **Rodney M. Goetchius** is 2nd vice president. . . . Those attending the dinner to meet and hear Dr. Wiesner at Endicott House in Dedham, Mass., November 2 were: Miles N. Clair, Horatio

L. Bond, Roy Sterling and James A. Pennypacker. Attending a similar affair in New York City on November 9 were: Clarence V. Chamberlin, Thomas E. Rounds and Lyman L. Tremaine. Although these will be reported elsewhere it seems to me the most interesting facts gleaned included statements made, that student unrest has visibly declined, students show awakened interest and pride in taking care of buildings and grounds and that where, in other colleges, administrators have dealt severely with militant students, courts have sided with offenders and finally, there is better all-round communication between students, faculty and administration.

As to news concerning our worthy classmates, there is little to say except that **Ernest W. Thiele** was honored with a degree of LL.D in May of this year by University of Notre Dame. . . . Also, that **Charles R. Goldstein** has been in the practice of law since 1928, the work more recently being confined to the rehabilitation program under the Federal Department of Housing and Urban Development.

Now to discuss as briefly as possible what seems to be becoming a burning issue relative to our 50th Reunion, a couple of ideas have come to my attention which might well bear some thought at this point. After reading **Pete Pennypacker's** comments in this column in the October/November issue, it is my feeling that we should go for the practice of class jackets even if there is some cost involved but only for male members of the class (let our coed classmates make their own decisions!), for the following reasons: (1) We only have one 50th. (2) Jackets or blazers, if attractive, and of light-weight material, can be used later for many informal occasions. (3) The class of 1920 looked very good at their 50th. (4) At this point in our lives will this expense deter many from coming? Ed Schmitz in a recent letter has given us some further ideas. He suggests uniformity for both men and wives using white jackets and red trousers (men) or red skirts (girls) or the reverse with contrasting hats and gray ties for men. Jackets would have emblems. Ed Schmitz asked me to put this in the column and encourage further comment and thought. Please send these to me and we will try to come up with some consensus or perhaps take a vote later if necessary. Personally I think we should decide on the basis of men only and do the simplest possible thing or forget it.

We are saddened again to hear of three deaths in recent months: **George K. Shands** on March 5, 1971; **Erwin G. Schoeffel** on June 13, 1971; and **Chester C. Taylor** on September 13, 1971.

We have two address changes: John S. Keenan, 235 St. Clair Ave. W. Apt 202, Toronto 7 Canada, CA 715; Louis A. Metz, RFD Box 755, Delray Beach, Fla., 33444—**Thomas E. Rounds,** Secretary, 4 Deer Hill Dr., Danbury, Conn. 06810

24

Being the Class Amanuensis does not necessarily mean that I am afflicted with a contagious disease. But, I do have lead time of two months and foresight enough, with the thermometer at 23 degrees F to wish you all a happy and healthful 1972. You will notice that I hedged on "prosperous" because as a realist and the Dow-Jones at 834, that word and the status quo are not compatible.

Gordon W. Harvey, '24

There is a dearth of class news just now, so in order to maintain my place for the future in the *Review* line, I will expand on some previous information. **Gordon Harvey** makes his move to Florida on October 18, official in a letter from 4503 King Palm Dr., Fort Lauderdale 33313. Sounds like they are pitching a tent there as he mentions "getting rid of a fine growth of assorted weeds." Hobbies will be duplicate bridge (one first-prize already) and golf, plus North in the summer months, contacts with Florida classmates and prospective Mexican Fiesta in 1972.

The Institute, as in past years, is needling the economy by yielding $2,253,000 to the City of Cambridge. This represents real estate taxes, and gifts in lieu of taxes, on M.I.T.-related properties for 1971. The Institute is the third largest source of revenue for the city, exceeded only by the public utility and the telephone company.

The broad activities of Governor **Luis Ferré** are indicated by his appointment as a co-chairman with Mayor Louis Welch of Houston, Texas, to the Governors and Mayors Committee for the 31st annual observance of National Bible Week, November 21 to 28. This is an interfaith effort to encourage Bible reading and study through Governors and Mayors who will participate in the proclamation and observance of Bible Week in their communities.

Our Environmental Laboratory Gift Fund solicitation progresses. There will be no separate environmental degree programs for either graduates or undergraduates, but currently many departments are offering educational and research opportunities in those aspects of environment closely related to their own disciplines. These may be discussed with a number of "environmental advisors" in each department. . . . My intuition last month, on **Bill Correale's** probable involvement in skyscraper fire hazards has now been confirmed by his letter. New York's Mayor Lindsay has named Bill to the Advisory Committee on Fire Safety in high-rise buildings. The Town of Brookline could very well use his expertise on the current revision of its building and zoning codes. Once the wealthiest town in the country, we are being infiltrated by 15-story jobs of questionable architectural charm.

On November 17, **Betty Kane** moved to her new residence at 7 Alford Rd., Great Barrington, Mass. 02130. This locates her about six miles north of daughter, Joanna (Mrs. Thomas Chaffee) who lives in Sheffield, Mass. We are very sorry to lose her from our community.

We note from our new addresses list that Professor **John H. Skinkle** has been piped out of Annapolis to his dock at 70 Bartlett St., Chelmsford, Mass. 01824. More changes: Homer S. Davis, 3747-104 Vista Compana S., Oceanside, Calif. 92054; Charles O. Duevel, 100 Sands Point Road, Sarasota, Fla. 33577; Ralph E. Johnson, 3247 W. Riverside Blvd., Rockford, Ill. 61108—**Russell W. Ambach,** Secretary, 135 Aspinwall Ave., Brookline, Mass. 02146

25

Mrs. **Andrew** (Edith Paula) **Meyer** of Orlanda, Fla., is serving as a national vice chairman for fund raising for the Unitarian Universalist Service Community in Florida. . . . **Samual R. Spiker** received a Certificate of Appreciation for efforts on behalf of M.I.T. in the 1971 Alumni Fund. . . . The following were registrants for the President's Inauguration Ceremonies: Professor Kenneth T. Bainbridge of Cambridge, Malcolm S. Blake of Norwell, Mass., John M. Campbell of Birmingham, Mich., Karl R. Van Tassel of Lake Forest. Ill., Samuel R. Spiker, of Conn., Samuel Glaser of Boston, Mass. and James H. Howard of Cambridge, Mass.

Frank Riegel has retired as advertising manager after 29 years with the Androck Co. He received the Worcester, Mass. Advertising Club's Silver Medal Award for distinguished service in advertising in 1970. He is past president of the Worcester Lions Club. Frank now lives at 158 Paxton St., Leicester, Mass. . . . **Millard L. Caldwell** is retired from the Patent Division of Shell Development Co., and parks his trailer in Mexico where he extends an invitation to anyone being in that region between November 1 and May 1. The address is Apartado 1320, Guadalajara, Jal. Millard has become interested in the Wally Byam Caravan Club and is president of the Mexicn unit. . . . **Bruno E. Roetheli** has just returned from a visit to Australia, Malaysia, and England. He speaks highly of the opportunities that Australia has to offer the young graduate or specialist in the business side of technology.

During a trip through Virginia with a few days in Williamsburg I took advantage of **Hank Hoar's** invitation to contact him and we had a very pleasant morning discussing M.I.T. and Hank's retirement.

He and his wife enjoy Williamsburg and Hank is quite busy with his activities in research work at the college library. He is living at 301 Indian Springs Rd., within walking distance of the library. His invitation to anybody in that vicinity to get in touch with him is renewed.

I have the following deaths to report: **Joseph J. Terrell** of Houston, Texas, June 27, 1971; Captain **Julien J. Edgerly** of Asheville, N.C., July 26, 1971.

I have had some correspondence and a telephone call asking why certain notices or items did not appear in the class notes as soon as expected. No apologies, but deadlines are quite a bit in advance of publication, particularly in the summer and early fall.—**E. Willard Gardiner** (Will) Secretary, 53 Foster St., Cambridge, Mass. 02138

J. Robert Bonnar, '27

George J. Taylor, '26

26

This month we have to report the loss of several classmates which is the unpleasant part of being class secretary. Four letters, starting with one from our Class Agent, tell the story, so we will quote directly from these letters. Pink Salmon writes, "Mary had a telephone call from Mae Criswell that Cris (**Wilbur W. Criswell, Jr.**) died on October 30, after a year and a half of illness. They had sold their house in Jupiter and moved to an apartment in the next town south about a month ago. Mae will continue to live there."

Marvin Pickett sent the following note: "**G. Richard Peterson** died in Fallbrook, Calif., on October 24. His sister, now living in Harwich Port, called to give the news. Dick was living in Fallbrook and had married again this past June. He leaves a new wife, a sister and a married daughter."

John V. (Vernie) Masterman, having noted the absence of any reference in the class notes to the death of **Lucien R.** (Luke) **St. Onge** in February of 1971, writes, "Luke was president of St. Onge, Ruff and Associates, Inc., consulting engineers specializing in industrial refrigeration and insulated structures. Luke's co-principal, and our classmate, **Al Ruff,** continues his activities as vice president of the firm bearing his name. Luke and Al both received Outstanding Engineer Awards early this year from Lincoln Chapter, National Society of Professional Engineers. Luke was a Fellow of the American Society of Heating, Refrigeration and Air Conditioning Engineers, and authored several technical papers some of which were included in the A.S.H.R.A.E. Data Book. He was the first president of the Central Pennsylvania Chapter of A.S.H.R.A.E., through whom a scholarship fund has been set up in Luke's memory."

Along with the sad news of the passing of a classmate, **Ken Lord** sends a bit of news about his latest activities: "It is sad to refer you to the funeral services of **Leland W. T. Cummings** of Philadelphia. Lee did much to elevate the reputation of M.I.T. around these parts.

"As for you, your wife, and the 'pup', we keep thinking we'd stop to say hello on our travels to Maine. Some day—but now we take the 495 belt, which takes us farther away from the Cove! Seeing Paul Mahoney's name in print, this will ask if he visits Saco and Biddeford summers? Put me in the retirement column. Besides a trust to close and work at a treasurer-ship, I've worked at a church one day a week, taken painting lessons, have been on the Boro committee, and played more golf than ever. And like them. Best regards. Ken." We appreciate the thoughtfulness of our four classmates in writing and for the Class extend sincere sympathy to the families of the classmates who will no longer be able to attend our reunions.

Classmate **George Taylor,** now retired, was recently honored by his profession as reported in the following news release: "George J. Taylor, a Fellow and past president of the Illuminating Engineering Society, has been awarded the Society's Gold Medal, the highest honor in the lighting profession, 'for the purpose of giving recognition to meritorious achievement which has conspicuously furthered the profession, art or knowledge of illuminating engineering.' Formal presentation of the medal was made at the I.E.S. Annual Conference in Chicago on August 20. The award to Mr. Taylor is a recognition of dedication for 38 years to the cause of modern illumination and the more accurate rapid seeing that better lighting brings to people." Our congratulations to George on this memorable occasion.

A letter has just arrived from our El Paso classmate who managed to get back home shortly before it became necessary to turn up the thermostat here in New England. **Ariel Horle** writes, "Having now arrived home after spending the summer on Lake Winnipesaukee, thought I would forward two pictures taken at Chatham that I thought turned out quite well. One is of the two representatives of III, Bill Forrester and myself. In the other I managed to include five members of the 1924-25 crew—Bill Latham, Art Underwood, myself, Mark Greer and Warren Hamblett. Hope the winds and weather treated you well this summer."

And that, we are pretty sure, uses up the '26 quota of space so until February, we will extend our usual Cheerio — **George Warren Smith,** Secretary, P.O. Box 506, Pigeon Cove, Mass. 01966

27

Bob Bonnar has retired from G.A.F. Corp. His last of very many assignments was corporate director of purchasing. To quote from *G.A.F. News;* "J. Robert Bonnar was saluted at a farewell retirement luncheon attended by his many friends and associates. Since everybody else was making a speech, Bob took to the podium himself and favored the crowd with a few selected reveries culled from 36 years at G.A.F.". . . And speaking of retired purchasing directors, **Jim Coburn** has been kept busy during the first two years of his retirement by "travel, golf, bowling, gardening, community affairs, good books, good friends." Jim has offered to send me a copy of the Shell Oil story as delivered at a meeting of the Newcomen Society to which he belongs . . . Also speaking of Bonnar: By the time you read this, your 1972 calendar will be in use and you can circle the reunion days, June 2,3 and 4, plus Homecoming at Cambridge Monday June 5.

The Class was represented at the president's inauguration at M.I.T. by Bud Fisher, Dick Hawkins, John Norris, Ezra Stevens and Bill Taggart. Johnnie Norris came from the farthest point—Marshalltown, Iowa. . . . I think I have mentioned that my chief "community project" right now is SCORE, a nationwide group of 4,000 retirees who act as volunteer consultants to small businesses. The organization is sponsored by the Small Business Administration. This month I attended the annual conference in Seattle and was delighted to see that **Harland Sisk** was also listed as one of the 150 delegates. Unfortunately, word was received that he could not attend but he did submit a report. So Harland had added SCORE to his other activities as treasurer of the Dennis and Yarmouth, Mass., school departments, and treasurer of the Cape Cod Standard-Times Neediest Families Fund. At the meeting I was very glad to find Gordon Miller, '28, whom I hadn't seen for those 44 years. . . . **Henry Steinbrenner** has a new address at 1400 Prince Charles Ave., Westlake, Ohio. I hope Hank is planning to take in the reunion again. . . . **Charlie Sanborn** has apparently retired. He worked for the

Post Office Department in New York and lived in Ossinning. He now has a new address at 10 Sullivan Rd., West Yarmouth, Mass. . . . **Joseph S. Harris,** Secretary, Box 654 Masons Island, Mystic, Conn. 06355

28

With the start of a fresh new year, your class officers and the "Boston group" wish each and every one of you the best of everything.

At the inauguration exercises for Dr. Wiesner and Dr. Gray in October, 1971, seven classmates were on hand to represent '28. They were Homer Burnell, Jack Chamberlain, Jim Donovan, Newton Foster, Bud Gray, Rudy Slayter, and Abe Woolf. **Jim Donovan** received a very warm letter of appreciation from Judith (Mrs. **Benjamin F.**) **Miller** in response to Jim's expression of sympathy from the class. We are much pleased and greatly honored to know that Judith wishes to continue her participation in class activities.

During the November meeting of the Alumni Advisory Council **Arnold A.** (Bill) **Archibald** was presented with the Bronze Beaver Award. This is the highest honor given by the M.I.T. Alumni Association. The citation reads: "Many years of dedicated alumni activity have given him an enviable record of service to M.I.T. As president of the M.I.T. Club of Western Pennsylvania, member of the Visiting Committee of the Department of Metallurgy, and member of the Alumni Advisory Council, his dedicated efforts have made him the personification of loyalty to, and interest in, M.I.T. His impact on the Alumni Fund—as chairman of the Leadership Gifts Campaign in Pittsburgh for several years, as an organizer and member of the Pittsburgh Area Alumni Fund Council, and as a member of the Alumni Fund Board—has been particularly significant and is gratefully acknowledged." Bill, to you from the Class—our heartiest congratulations!

At the fall meeting of the American Society for Testing and Materials, New England District your secretary met **Dave Mathoff.** Dave said that he had had a recurrence of his heart trouble which put him back in the hospital for three months in September. He is concentrating on getting his health restored and says that Dora is a great help to him.

As many of you know (some by experience), the Alumni Office periodically conducts an event called a telethon, an evening of telephone calls by volunteers to their classmates for the purpose of promoting the Alumni Fund. It also provides the opportunity for news gathering and is thereby a boon to the author of class notes. If you should happen to be one of those called (it can be anywhere in the country) you will have the chance to get your story to us without the chore of writing it. On a day in early November **Ford Tibbetts** drove to Cambridge from New Hampshire to join Jim Donovan for such an evening of telephoning. They report that everyone was friendly and pleasant to talk with. Many were already looking forward to the 45th reunion. Others who had not given the matter much thought had their interest stimulated. Following are some notes from the conversations: **Elwood Anderson,** our old southerner, is now retired after 40 years in industry, much of it with Ethyl Corp. He has remained in Baton Rouge. His first wife gave him three daughters. Following her death he remarried and thereby acquired three stepsons. Andy said he was very glad to have been called. . . . **Gordon Rogers** in Berkeley, Calif., said that he is retired and enjoying the good California weather. He has great hopes of making it east for the 45th. . . . **Ed Durbeck** is retired. He says the money available to him hardly stretches to any more than his 17 grandchildren. That's a complaint? . . . **Alex Dukelski** is retired and living in the Los Angeles area. He was not aware of any other '28 architects in his vicinity. . . . **Joe O'Hearn,** in Washington, D.C., said that he had retired after many years in the Department of State. His son, who has done well, was in Vietnam at the time of the discussion. Hopefully he will be back home by the time Joe is reading this. . . . **Ward Bloomer** is still going strong at Lummus Co. after 40 years. We understand that he is technically retired but still at work every day. Ward now has 65 patents in his name. . . . **Ted Hubbuch** reported that he had been with the Army Chemical Corps until their plant shut down in Florence, Ala. This being his favorite town, he stayed on to teach chemistry at Florence State College. Like many others, he hopes to be at the 45th.

Bob Harbeck has his plans all made for retirement in 1972. He has pleasant memories of the 15th and 25th reunions and wants to be at the next one . . . . You may recall that **Willy Beard** was the classmate that started taking flying lessons and married his instructor. He reports that they are still flying together. . . . **George Hoffman** is still with White Superior Division of White Motor Co. in Springfield, Ohio. He plans to retire soon but hopes to continue work as a consultant. His grown son is in the automobile business; he has an 11-year-old still in school. . . . **Clifton Edgar** said that he is now retired (New York Telephone Co.). We are sorry to learn that his wife is an invalid. . . . **Gerard Lake** is still working hard and wrestling with problems of the family business. . . . **Jean Roberts** is still at University of Virginia as professor of electrical engineering. . . . **Charlie Southwick** had the misfortune to break a leg over a year ago. It has been slow to heal but Charlie is just as enthusiastic as ever about life. He and Margaret look forward to the 1973 reunion. . . . We are very sorry to report that **Merrell R. Fenske** died September 28, 1971. Dr. Fenske, who for many years was head of the petroleum/refining laboratory at Pennsylvania State University, had been on the faculty for 41 years and retired last year as professor emeritus of chemical engineering. The author of a technical volume on petroleum refining that became an international reference manual, he was also the recipient of several awards: in 1964 the Redwood Medal of the Institute of Petroleum in London and in 1966 the national award of the American Society of Lubrication Engineers.—**Walter J. Smith,** Secretary, 209 Waverly Street, Arlington, Mass. 02174.

29

I am sorry to announce that **Joseph F. Clary** of Vero Beach, Fla., passed away on September 21, 1971. He retired a few years ago as vice president of the Edward G. Budd Manufacturing Co., of Philadelphia. His work involved the development of modern railway passenger cars and equipment. He is survived by his wife Elizabeth and a sister, Mrs. Benjamin B. Treadway of Chevy Chase, Md.

Emmette F. Izard, Course V, Hazelhurst, Mass., retired January 1, 1967 after over 37 years of service in various research divisions of the Dupont Co. He has a summer home in western New York and spends winters in Mississippi. . . . **Peter P. Gnoocheff,** of Los Angeles, Calif., writes, "I had been working for an architectural firm for about 20 years. Due to lack of work in the firm, I have been unemployed for about a year." . . . **Dexter S. Osgood**, Malverne, N.Y., retired from American Tel. and Tel. on May 10, 1971 after 42 years of service with the Bell System. . . . **Donald S. Hersey**, East Hartford, Conn., sends thanks for the birthday card he received from your Secretary and writes, "Retired from Pratt and Whitney Aircraft in 1967 after 38 years of service. My wife, Elenor and I have enjoyed these past four years, traveling some, visiting friends at their vacation cottages and keeping busy with our hobbies which include picture painting, music, theater, literature and golf."

Dr. Myron Tribus, Senior Vice President of the Xerox Corp., speaking before the 19th Annual Hydraulics Division Specialty Conference on August 18, 1971, at the University of Iowa, paid a high tribute to **Hunter Rouse** of Iowa City, Iowa. While delivering his speech on "Integrity and the Ecological Crisis," he said, "When I received the invitation to speak at this conference my first inclination was to turn it down . . . but when I learned that the conference was to be dedicated to Hunter Rouse, I could not decline, for, quite unknown to him, he was an important influence in my career, and I feel I owe him something. In preparation for this talk, I did a little research on Hunter Rouse and I came up with some information you may not know. When he first showed up at M.I.T. and was pledged to Sigma Chi, his classmates recall that they let him in with some reluctance as he did not have a Stutz Bearcat or a raccoon coat, and he gave the overall appearance of a kid fresh from the farmland, which he was. However, appearances are deceiving, for I have been told that he went on to be president of his chapter twice and established the highest scholastic record the fraternity ever had . . . I'll wager that very few of you know that Hunter Rouse supported himself through college as a professional ventriloquist! There are still people around who remem-

ber him sitting motionless and expressionless while the dummy sang an aria from *Aida*. It was from this sort of start that Hunter went on to his studies in Germany and, thence, to the beginning of a career which has brought him ever greater influence over the years."

Carl M. F. Peterson, writes, "In June, 1971, I retired from M.I.T. as director of the Physical Plant. I had been at the Institute since graduation in 1929; first as a member of the Mechanical Engineering Department, and later in the Physical Plant Department. My son Richard is with General Radio in Concord, Mass., and my daughter Carol, is in Denver, Colo., working in a computer group. My wife Dorothy and I have taken up residence in Green Valley, Ariz. We hope that the climate here will permit us to be active outdoors 12 months of the year. Although we have been out here only a few months, we have already made many friends and we are very busy, traveling, hunting, fishing, and we both enjoy golf." . . . A note comes from **Sidney Darlington,** "I retired from Bell Telephone Laboratory on July 31, 1971 after 42 years of service. However, for at least a year, I am a consultant to Bell Labs two days a week on transmission systems. I have also just become an adjunct professor at the University of New Hampshire, with minimum duties (not yet defined). My wife Joan and I moved to a new house in Durham near the university and we have an ancient cottage in Randolph, N.H. Our two daughters are still very young, aged one and a half and four and a half years. We are more than fully occupied."

Richard K. Opper, Walcott, Conn., has sent a note saying "It was a pleasant surprise to receive a birthday card on my 64th birthday from the Class of 1929. Currently, I am the president of the Naugatuck Y.M.C.A. (seventh year) and president of the Wolcott Historical Society. I live in a 10-room house built in 1790 filled with antique furniture. I will be retiring from Uniroyal, Inc., in September, 1972 after 43 years of service. I am just very happy living my life." Richard will be very happy to hear from any Twenty-Niners who happen to be in Connecticut. His telephone: business (203) 729-5241 and home (203) 897-1258. . . . **Jack Dietsch,** Seattle, Wash., writes, "Dear Karnig, So as not to embarrass you, I am not an M.I.T. graduate! I did graduate from Northeastern University in 1927 as an 'E.E.' Then I took some extra courses at M.I.T. in 1927-28. During the Depression, I took what job I could find and so I switched to the 'M.E.' field, which I followed until my retirement last year from Lawrence Radiation Lab (part of the University of California—and now called Lawrence Livermore Lab) contractors to the A.E.C. I spent the last 15 years with them designing, following the manufacture and supervising the field installation of all sorts of equipment associated with atomic tests at the Nevada test site and elsewhere. So now I am 'working' at my retirement program and haven't settled down yet into a comfortable routine. Regards."

John G. Howell, Jr., Piedmont, Calif., has sent a note saying, "Retired as of September 30, 1971, after 34 years of service with Owens-Illinois, in the general engineering department, Pacific Coast. I was a principal engineer for plant facilities for ten plants on the Pacific Coast. Our older daughter just graduated from law school and has taken the bar examination for California. Younger daughter is married, living in Honolulu and loves it. For the past year I have been program chairman and vice president for a Breakfast Club, with 52 programs to arrange. This will keep me busy for some time during my retirement. Just returned from a trip with my wife Kay, to Greece, Turkey, Russia and Yugoslavia. The Greek Islands were fantastic, hope to go back again soon, especially to Rhodes and spend more time learning about the wonders of their earlier civilization." . . . **Phil W. Sayles,** Scarsdale, N.Y., writes, "I am about to retire (October, 1971) at the age of 65, after 44 years of service with General Electric. For the past few years, I have been in New York as a consultant—Marketing Personnel Placement. We maintain an inventory of high-potential marketing people and select and recommend candidates for open positions company-wide. Our son Jeremy and his wife have presented us with our first grandchild, born on August 27, 1970. Our daughter Meredith was married in October, 1969, in Teheran, Iran where she and her husband were in the Peace Corps. We will continue to live in Scarsdale for a while and do some traveling. Later on I intend to do some consulting and our plans are to move into northwestern Connecticut eventually."

Raymond Underwood, Lansdale, Pa., writes that the only thing new with him is a new house number—he has had the same wife (Freda), the same house and the same job (patent attorney) for the last 40 years. "Patent work" he continues, "has been exciting and has gotten me around a lot, but now the company is phasing me out. Then I will do some free-lance patent work, keep working on our farm and continue traveling."

A birthday card to **Carl G. Wennberg,** Hingham, Mass., brought a sad note from his widow that Carl passed away on December 27, 1970. Her note continues, "Until about six years ago, Carl was president of Special Tool and Machine Co., a family owned and operated business. It was then sold to Texas Instruments and Carl was retained as a production specialist until his death. Thank you for your kind note."

Harold A. C. Dahl, Westford, Vt., writes: "Out to pasture after mandatory retirement from General Electric (Burlington). I have now gone into seclusion on my 'vast' (nine-acre) estate in the wilds of Westford, Vt. Outside of a few activities such as church, regional planning, Civil Board of Authority, Blue Lodge, Scottish Rite, Shrine, U.S. Coast Guard Auxiliary, not to mention nine grandchildren, I sit in a rocking chair and twiddle my thumbs. My main complaint is that I have no regular job to which I can go to rest."—**Karnig S. Dinjian,** Secretary, Starlight Towers, Apt. 14 E, 6000 North Blvd., Fort Lauderdale, Fla. 33308

T. A. Riehl, '30

30

Although I haven't gotten around to making a detailed survey, it seems to me that the proportion of our retirees must be approaching the 50 per cent mark. Certainly the retirement rate has increased markedly in the last year or two, even though we are statistically some distance from the traditional retirement age. . . . We have at hand a notice concerning **Ted Riehl**'s retirement as of July 31, 1971 from Gooodyear Tire and Rubber Co., for whom he had worked since graduation from M.I.T. After joining Goodyear in 1931, he began an eight-year assignment in the research department during the course of which he was involved in the development of the first rayon cord tire which Goodyear introduced in 1938. During World War II he became involved in the development of synthetic rubber tires. In the course of his retirement interview Ted pointed out that "there were many who said synthetic rubber could not be developed to equal natural rubber. Now more than 75 per cent of the rubber used in tires in this country is synthetic." In 1955 Ted was named manager of product development compounding and in 1964 he became chief chemist in tire development. In 1969 he was named director of compounding. Ted and Margaret have two married children and are planning to do some travelling now that Ted has retired.

Ralph Draut retired in April 1971 after 41 years in the aircraft industry. According to my records, he was chief structures engineer at the Office of Supersonic Transport Development of the Federal Aviation Agency. . . . **Ed Nolan** retired from Merck and Co., about two years ago and as of this writing is arranging speaking engagements for a young man campaigning for election to the New Jersey State Senate. He and his wife will spend the winter months at their Palm-Aire apartment in Pompano Beach, Fla. . . . **Frank Hankins** is an old hand at the retirement business, having retired from Lockheed at the end of 1966. He says his activities are "those of a very busy retiree involving upkeep of my home which is on something over eight acres." He is also "in effect, the greenskeeper who provides what it takes to keep in shape, for the neighbors use, a huge playground complete with facilities for swimming and tennis. Frank's son Timothy recently received a degree in radio-astronomy from University of California.

At the 61st National Council Annual Meeting of the Boy Scouts last May, **Bill Jackson** received "Scouting's highest award, the Silver Buffalo." Bill was previously president of the Allegheny Council in Pittsburgh and served for the past seven years as an executive board member of the National Council. As previously reported in the notes, he is president of Pittsburgh-DesMoines Steel Co. . . . **Walter Soroka,** professor of mechanical engineering at University of California, Berkeley, has been appointed Dean of Continuing Studies at the University. He was chief consultant on acoustics when the new San Francisco Auditorium was built, as well as chief consultant when the San Francisco elevated system was constructed. . . . **Bill Dickerman** reports that he and Marion spent a delightful summer on Nantucket and are now back in Greenwich. He makes frequent trips to Manhattan where he has a consulting client. . . . **Tom Emery** is a self-employed accountant and tax consultant in Birmingham, Mich. The Emerys have a married daughter and two grandchildren.

Changes of address: Lawrence N. Gonzalez, 922 24th St. N.W., Washington, D. C. 20037; Langley W. Isom, 23 Gordon Lane, Yarmouth Port, Mass. 02675; E. Stephen Prendergast, Box 651, East Orleans, Mass. 02643; Robert W. Reynolds, 161 Bay Lane, Centerville, Mass. 02632.—**Gordon K. Lister,** Secretary, 530 Fifth Ave., New York, N.Y. 10036

31

Best wishes to you all for 1972. . . . **Charles Loucks** writes that he manages to keep busy with personal affairs, running a home in Arlington, Va., and among other things, doing committee work in a number of state, veteran, civic, patriotic and similar organizations. Last May, he visited members of his family in California and took a side trip by way of the Inside Passage cruise as far as Skagway, Alaska. . . . Congratulations to **Howard Richardson** and **Bill Jacobs,** who were awarded Certificates of Appreciation by the Institute for their efforts on behalf of the 1971 M.I.T. Alumni Fund. . . . A note from **Frank Weeks** mentions that he ran into the president of the country club where we had our 40th Reunion during a cruise to Africa in February, 1971.

A most welcome letter from **Emile Grenier** brings us up to date on his activities. "As you undoubtedly know by now, our 40th Reunion was deemed to be the best ever by a great many of those present with whom I talked about it on Monday. I guess it comes from a feeling of friendliness that had developed thru the past 35 reunions in which a great many of us who did not know each other well, if at all, have gotten to be on first-name speaking acquaintance. It is always interesting to see who is new as well as meet the old standbys. The location was superb and one that all who were there for the first time will not fail ro recall from time to time in the years ahead. I don't know who zeroed us in on the place but it would be nice of you to give him a credit line.

"I recently received a patent covering a device—a very simple strap which holds the shoulder belt in a manner that takes the actual contact and likewise pressure off the neck while it is in position. The patent is also in Wm. Sobknow's name (an associate at Ford) and assigned of course to Ford Motor. The Ford Tot-Guard which I designed in 1967 is finally beginning to move in appreciable volume. You might be interested to note the advertisement in the June 14th *Time* page 50 or the same one in *Newsweek* on June 7th in which mention is made of it. I shall send you a four-page brochure on it which is being printed by Ford for release in July. When I was graduating in 1931, Dean Lobdell called me into his office and offered me a possible job with Shreve, Crump and Lowe in Boston. He said, 'Emile, most graduates in engineering don't end up in their field of study.' He was right of course but I told him I still would go on trying to get into the aero field. This all by way of leading up to the fact that the most important thing I have created in the years since I completed Course XVI (aero engineering) is a device to prevent children from flying.

"You will undoubtedly recall the most famous speech of Professor 'Tubby' Rogers on the subject of marrying the boss's daughter and the speech made outside the Harvard Stadium the following year by the Ivy Orator, which was 'Be a Slob'. He sure put forth some very impressive arguments. At the time, I was sure his words would suffer the fate which Abraham Lincoln predicted ('the world will little note or long remember what we say here'). However, my several trips thru Harvard Square convinced me that he had succeeded.

"As an individual who has worked closely with the development of the Airbag (a joint project of Eaton Yale and Towne with the Ford Motor Company), and as an aero engineer gone automotive safety, I would like to make the following observation: The Airbag will never make it into automotive production, no matter how hard Ralph Nader pushes, until the flying public comes to their senses and demands individual ejecting seats each equipped with its own chute and life raft. (Somehow this reminds me of MacBeth.)."

From all reports, the 23rd M.I.T. Fiesta in Mexico this past year was a great success. Classmates who attended included Evelyn and Howard Richardson, Alice and Al Pierce, Antonio Chemor and Albino Arce. . . . Charles Norris, Professor of Civil Engineering and Dean of the College of Engineering at the University of Washington co-authored an interesting article, "Educating the New Breed of Engineer" which appeared in the July issue of *The Trend in Engineering* published by the University of Washington.

Since the last Class Notes, word has been received of the death of the following classmates: **Nathaniel Coburn** on June 22, 1971 (At the time of his death, Dr. Coburn was Professor of Mathematics at the University of Michigan.); **William N. Boynton** in December 1958; **Oscar Lilja** on September 28, 1970; and **Paul Hartman** on April 4, 1971. Our deepest sympathy to their families.—**Edwin S. Worden,** Secretary, 35 Minute Man Hill, Westport, Conn. 06880

33

Here we go again, but, with about the smallest contribution in many a year. Perhaps we can make it all up in quality. I sent out a dozen or more cards of supplication, and got three replies—25 per cent is about par. I must give top billing to **Mal Mayer,** beer expert-extraordinaire, because his nice letter was the only unsolicited message. Mal's partial retirement in Washington, Maine, seems to be more than hectic what with the fine weather causing a larger influx of visitors. The Mayer plans appear to be firm. The first week in December, Mal and his wife will stop at the Institute to visit with Julius Axelrod, the Nobel Prize winner, then on to Ontario and Chicago. They have an apartment for January in London (which must mean Ontario). The holidays will be passed with the family at the above locations. Then, on to Carmel, Calif., for February; March and April will be spent in Australia and New Zealand; why all this traveling, Mal does not mention, but it must be the beer business. Mal will be spending more time in Maine from now on, as daughter Barbara has moved from California to Augusta, Maine, where she has taken a new job. Mal, I sure appreciate your continuing interest in the class, and I also wish that more of the boys would "go thou and do likewise".

From **Ivan Getting** comes welcome news of his lovely family. The eldest child, Nancy, is married to Dick, and they live in Green Bay, Wis., with their four children. Son, Pete and Marna have one child, Ingrid. Pete spent the summer at Berkley, finished his Ph.D. and is now doing neuro-physiology research at the University of Washington. The middle child, Ivan Junior, is still at U.C.L.A. and is not yet married. If a busy man like Ivan can spend six minutes writing the secretary, you fellas can too. Ivan, it is always a pleasure to hear from you. . . . Now comes a full card from one who is probably our most faithful, loyal coed, **Vivian Drenckhahn.** She writes about her busy life in world health affairs. She has been honored many times by her peers in health science. Her card is terse and factual, so I'll quote since I can't tell it any better than she did: ". . . hope you will be successful in getting a few '33 girls to attend the 40th Reunion. I may even make it. In mid-March, 1971, I completed a six-month assignment in health education as a consultant, in Bangkok, Thailand; this a part of the World Health Organization. So, four weeks in Bangkok, then a few days at the S.E. area W.H.O. Regional office in New Delhi, and the remaining time in Geneva, Switzerland at the W.H.O. headquarters. On April 24, 1971, the College of St. Benedict, St. Joseph, Minn., presented me with an outstanding

Alumna Award (the first given) and the President's medal. This award was presented at College Day festivities. The annual meeting of the Society of Public Health Education was held in Minneapolis October 8-10, in connection with the A.P.H.O. meetings. I was an active participant in the Society meetings." We are proud of you and your work in health science and we appreciate your continuing loyalty to M.I.T. and to your class.

Mention of **John Wiley** is made in a release by the A.I.A.A., announcing a panel of which John was a member. The panel of five treated the subject, "S.T.O.L. and V.T.O.L., where do they fit?" Well, so I say, "Where indeed, and what is it or they?" The release is so short and terse, it's a bit painful. Perhaps John will tell us more, but he's gotta volunteer. No more publicity for these characters who won't write ye scribe. . . . From **Henry Kiley** we get an apology for his lack of news, but he did write, mostly to say that he enjoys the class news. Others would enjoy them more if fellas like Henry were to offer something. However, when he gets in the mood, he will give us a bit. So, we thank Henry, hopefully. . . . One change of address: **William E. Baur.** Bill has now moved to Dundedin, Fla., and most aptly, lives in a mobile park, titled "Honeymoon." I expect that the name is well earned as Bill has always been a sort of honeymooner anyway, since he and his wife are always travelling.

From alumni records we have word of the passing of **Marshall P. Wilder,** one of our own mechanicals. As your representative, I extend to Mrs. Wilder, our most sincere sympathy in her hour of grief.

Berj Tashjian, one of our architectural friends, writes at length, with news of his family. Berj has just finished managing a Northbrook, Ill. Pony League baseball team to a championship and a "World Series." The team won 20 out of 23 games, and went on to fame from there. Son, Eugene, batted 500 for the complete season. This is most interesting to me, for I too am quite interested in Pony League work as Fort Rock Farm has sponsored a team in pony for 8 to 9 years. Daughter, Charmion, is a 1971 graduate in music from Northwestern, and received the Sigma Alpha Iota Sword of Honor and Leadership Award. She is to go to Stanford this fall for her master's in musical composition, with a minor in humanities. Her composition, "Armenéchos" received enthusiastic acclaim at the student recitals. Berj has two other children in high school. Berj, this note has really been a pleasure. Talent has quite apparently been inherited, as those kids must be a joy.

Forrest P. Dexter, Jr., sends announcement of retirement. I hope a few of you characters can keep on for a while at least. Forrest will retire to Wilton, Maine, after ten years of industrial research, and 26 years teaching in college. This latter, and lecture tours have made his last year go by awfully fast. He asks, "do you remember Beaker Joe Phelan, A. A. Ashdown, Professor Copithorne, H. W. Shimer, and Ham Buerger?" Some I do, Forrest; thanks for the note. . . . Now comes **Ellery D. Clark, Apollo structural designer deluxe,** and an old friend to boot. Ellery and Louise have just returned from a two-week deluxe tour of four Hawaiian Islands. Son Steve is still in college, daughters Virginia and Margie are both married, but Ellery is still not yet a grandpaw. Ellery says he plans to attend our 40th reunion. Many thanks for thinking of us.

I have one late bit to add to this forlorn tome: I had the pleasure of attending a meeting on November 6, at the Union League Club in New York, of a small group of alumni interested in Alumni Fund work, addressed by Dr. Gray, our new Chancellor. It was a most inspiring and very frank talk on the present problems of our beloved school, touching on the fields of finances, curriculum changes, student participation in university management, the present status of research, the minority group situation, and more. A question and answer period then followed for better than an hour. The questions were of a very searching nature and Dr. Gray was most frank in his replies. Some samples: the present cost of the students' education is now paid for less by the student than by other sources, about 30 per cent. Research proceeds about as before, except that the Draper Labs are no longer pursuing their original objectives, this type of activity, no doubt, being handled elsewhere by the army and navy, probably in places where that type of work should have been done in the first place. So weaponry appears to be out so far as M.I.T. is concerned. Dr. Gray went on to say that some black students have been admitted to M.I.T. lacking full requirements of admission, but explained that this one aspect is the only one where the minority group is favored, and for excellent reasons. The applicant receives some consideration for the fact that his secondary school might not have had accredited standing, but the applicant himself proved conclusively that he personally did have what it took. That is the only lowering of any bar whatever. They must attain and maintain the exact same grade levels as all others, without exception. I put this in to reassure our readers of this misunderstood situation.

Now to all of the fatihful, a very Happy New Year, with the hope that with a brand new year, you will all remember that your secretary is a news-hound and not a fund-raiser. You can tell me anything and it will appear here after editing. A note to me is not a lead to your being asked for a contribution.—**Warren J. Henderson,** Secretary, 1079 Hillsboro Beach, Pompano Beach, Fla. 33062

35

The President's Cup, emblem of golf supremacy for our class for the last 11 years, has been retired permanently. **Ham Dow** did it by winning his match in the finals with Sam Brown in the 11th Annual Tournament ending in October. He had previously won the cup in 1967 and 1968 and his 1971 triumph puts all three legs on the trophy. Congratulations from us all, Ham, for your wonderful perseverance over adversity and golfing opponents. The consolation match came down to the wire with **Ned Collins** just edging out **Bill** (Hole-in-one) **Bates** by a single stroke. Congratulations to you. Since 1969, when I was serving as Class President, I prevented Ham Dow from retiring the Cup by winning the finals from him on the 19th hole that year, I am announcing that I will place a new trophy into the competition beginning with our 12th Annual Tournament in 1972. It will be known as the President's Trophy and again, can be retired permanently by the first golfer to win it three times. '35ers attending the President's Inauguration October 7 included: Bill Abramowitz, Leo Beckwith, Charles Bowen, Carbon Dubbs, Pete Grant, Allan Mowatt and Prescott Smith. The Inauguration ceremony concluded an interesting and exciting two weeks of seminars, panel discussions and related events.

We have just received word of the death of **Frederick L. Stephens** on June 15, 1971. He received his B.S. and M.S. in Course X-A with us and was employed at the Colgate Palmolive Co. in Jersey City. We would appreciate any information from those of you who were acquainted with him. We are particularly interested in learning if he was married and where his widow might be located.

I am sorry if you non-golfers in the class are upset by all the golfing news in the notes, but to be brutally frank, it's your own fault. If you want news of something else, you have to produce it by writing to me, or having your wife write to me. Let me hear from you one way or another as I would surely like to share what you send with the rest of your classmates. How about making a New Year's resolution right now that you will write to your Class Secretary in 1972. Follow it up soon, because we are in the non-golfing season as far as our Class Tourney is concerned, so that even the golfing news will be missing for a while. And a Happy New Year to you and yours.—**Allan Q. Mowatt,** Secretary 61 Beaumont Ave., Newtonville, Mass. 02160

36

Each time the Alumni Office sends a list of address changes I am reminded that many of us are moving to warmer climes. Fred Carten has left Washington, D.C. for Boca Raton, Fla., 251 SW 7th Ave., 33432 and Homer Webster to Hanaki Kavai, Hawaii (Box 33, 96714). Preferring snowshoeing myself I am not tempted to follow their example. . . . **Harry Essley** sent a note to our reunion from Kingston, Jamaica, where he and Betsy have spent the past year aboard the *S.S. Hope.* Harry was responsible for keeping the medical equipment functioning. This ran the gamut from sterilizers, x-ray, film processors, and many more to I.B.M. typewriters. They found the people with whom they worked most interesting and had some time to explore Jamaica. By now they should be back in Rochester, N.Y. . . . The firm of Rath and Strong, Inc., in Lexington, Mass.,

has offices in Chicago and San Francisco and work in Holland and Great Britain. This keeps **Dorian Shainin** on the move but he feels that "the challenge of problem solving, by both analytical and creative methods, continues after 19 years of this work to make up for the rigors of the travel schedule." The Shainins have two grandsons and by now probably a third grandchild.

Jim Patterson wrote to several classmates and the following comments come from some who were unable to attend our reunion. **Laddy Reday** in addition to providing residents of Orange County, Calif. with soft water has been "up to his ears in real estate" and teaching at Golden West College in Huntington Beach. With a daughter graduating from high school and an Argentine daughter for the year (A.F.S.) leaving southern California was not possible. . . **Art Sarvis** who is with the G.E. Lamp Division in Cleveland has moved into an apartment following the death of his wife. His new address is 2201 Acacia Pk. Dr., Apartment 323, Lyndhurst, Ohio 44124. . Business and family kept **Chet Meyer** in Pewaukee, Wis. He comments that he may not produce another hockey player but there is a good chance he will have produced a ski racer one of these days. Chet's oldest daughter is a Wisconsin graduate and the second is in college now. . . . **Bill Hope,** too, found that business pressures would keep him from attending. The Hopes enjoy living in Durham. N.H., and Bill finds being married to a grandmother "not bad, either." . . Mary and **Bill Mullen** wrote a note after they returned west following their vacation in Europe which ended with the reunion. Bill is a construction cost consultant with offices in Glendale, Calif., and hoped for one or two jobs when he got back. Within three days he had nine on the calendar and will need another vacation to recover. He isn't the only one as I am sure you well know. **Larry Kanters** reported coming back to mountains of paper work after he and Zee vacationed in Israel where they have a married daughter. For me the paper work mounts even without a vacation.

Indirectly, I have learned of the death of **Arthur Sedoff** although I do not know the date. **Alice H. Kimball,** Secretary, Apt. 8-6C, 100 Memorial Dr., Cambridge, Mass. 02142 or P.O. Box 31, West Hartland, Conn. 06091

37

Al Woll writes, "last April, our daughter, Helaine (Fendelman) presented us with our second grandson, Jonathan in Scarsdale, N.Y. Our son, David, was married to Leslie Finkel of Council Bluffs, Iowa over the Labor Day weekend. David is a graduate student at Columbia University where he will receive his master's degree next summer in the field of urban development. Our third child, Susan is now a sophomore at Washington University (St. Louis). On July 1 I stepped down from our local school board and its presidency after serving over 12 years. To take up the slack, and then some, I accepted the presidency of the Evansville Rotary Club. In addition, I was elected to the board of trustees of Indiana State University of Evansville foundation. I have been swapping notes with **Milt Lief** who resides in the St. Louis area. Milt too was elected president of his Rotary Club. We have been talking about taking in the Rotary International Convention this coming June in Houston, Texas. It looks like our 35th is due in June of '72. Certainly hope to see you at the reunion." Well, Al, as you might suspect, our reunion committee held a meeting the last of October at Phil Peters home in Wellesley. Duties have been assigned and plans are underway for a grand time starting Friday, June 2, and running through Monday, June 5, 1972. The location on Cape Cod at the Chatham Bars Inn will live up to your every expectation. Plan to join your classmates with their wives at your 35th reunion. It only happens once in a lifetime.—**Robert H. Thorson,** Secretary, 506 Riverside Ave., Medford, Mass. 02155; **Curtiss Powell,** Assistant Secretary, Rm-5-325 M.I.T., Cambridge, Mass. 02142. **Jerome Salny,** Assistant Secretary, Egbert Hill, Morristown, N.J.

39

Colonel **John C. H. Lee, Jr.,** U.S.A., formerly director of Appalachian Studies, Corps of Engineers, at Cincinnati, wrote that he has retired from the army and is now consulting a bit, as well as serving as associate professor of civil engineering at the University of Cincinnati. . . . **Dudley H. Campbell** also wrote that last June he was elected vice president—engineering, of the Stack Pole Carbon Company, St. Mary's, Pa.

While making an engineering sales call at the General Electric Company's Plainville, Conn., plant, I was surprised to hear a voice say "You look familiar!" It was **Charlie Hobson** who recognized me in the corridor. He is project development engineer for industrial circuit breakers, in G.E.'s circuit protective devices department, working on molded case circuit breakers, both electronic and solid state versions. The Hobsons live in nearby Southington. Mark is a German teacher in Port Jefferson, Long Island; Joan's husband is in Vietnam; and their youngest, Bill, is a junior at Bucknell. . . . **G. Woodford Thomas** was among ten alumni awarded a Certificate of Appreciation for his work as a regional chairman of the 1971 Alumni Fund. His work was with the Columbus, Ohio region.

Represented at the President's Inauguration (according to the registration list) were the following thirty-niners: William S. Brewster, Wayne J. Hulman, Mrs. Ruth B. Pitt, Burton C. Rudnick, Louis D. Smullin and William Walker.—**Oswald Stewart,** Secretary, 3395 Green Meadow Circle, Bethlehem, Pa. 18017

40

In the last issue of *Tech Review,* we reported the death of our classmate, **Bradley Newcomb.** We are indebted to the *Review* for the following letter from Mrs. Phyllis Newcomb: "It is with great sadness that I inform you of the death of my husband Bradley, on August 2, 1971 at Massachusetts General Hospital. He had undergone open heart surgery on July 29 to correct an aneurysm which had developed as the result of a heart attack in March. At this time I am enclosing a contribution which was mailed direct to me. I had requested memorial contributions to the Alumni Fund, Class of '40 in the name of Bradley L. Newcomb in lieu of flowers. Certainly would appreciate the names of contributors so that I may thank them personally, otherwise I have no way of knowing. Thank you for your assistance in this matter."

From **T. Stewart Harris** there comes the note that Dave Haskett was recently married to Miss Margaret Doyle. Dave's first wife died in 1969 after a long illness. . . . **H. Tyler Marcy,** Director of Technology of I.B.M. Corp. in Armonk, N.Y. has been elected president-elect and secretary of the Instrument Society of America. Tyler has been with I.B.M. since 1951 and prior to his present position he was assistant to the president of the systems development division.—**Al Guttag,** Secretary, Cushman, Darby and Cushman, 1801 K Street, N.W., Washington, D.C. 20006

41

Being new on the job as Class Secretary, I didn't realize I should have very guardedly used the press releases sent to me, and doled them out issue by issue, since there was a decided dearth of activity this month. Apparently your activities have been such that they were not designed for the press. . . . I did hear on the radio that **Howie Samuels** is interested in extending his off-track betting operations to other activities and I am sure Howie is going to "give it to me" for this.

We have by now all received our discs from the Alumni Fund and hopefully you will all listen to it carefully, send in your donation, and include some personal data about yourselves. Just nore something on the flap of the envelope or insert a short note about your activities, and it will be forwarded to me. There are a lot of your classmates who are interested in hearing about you and if the information doesn't reach me there is no way to disseminate it. Your secretary is embarrassed to find he forgot to respond to the drive last year, and as a result is not receiving copies of the *Technology Review.* I therefore have no idea what I have written the past two months. To guarantee sparkling information next month, please include those personal notes with your contribution.

A special N.A.S.A. release on the passing of **Stanley Smolensky** reached me, and I thought you would be interested in a personal quotation, "a hell of a nice guy." We all concur about that. This release also suggests that contributions be made to the Heart Fund in Stanley's memory. No doubt you have already sent notes to his family but if not, his current address as shown on our

R. B. Finch, '41

records was: 5710 Court Lane, New Orleans, La.

I brought to your attention last month **Oscar Mapua**'s concern about a new president for the college in Southeast Asia which is so crucial to the development of technical personnel in that part of the world. Those of you who may know someone interested in this, please write to me and I will send whatever information I have, or write to Oscar personally at Mapua Institute of Technology, Manila, Philippines.

I am happy to report that **Luke Hayden** is recovering very well from that surgery of his, and his associates report he is working much more than they had thought possible after his serious surgery. Good news, Luke. . . . News has just reached us about **Rogers Finch,** who has had one of the most colorful careers of anyone in the Class of '41—from the Point Four program in Rangoon, Division of University Relations with the Peace Corps in Washington in 1961-1963, vice president of planning for Renssalaer Polytechnic University in Troy, N.Y., member of the faculty at M.I.T., not to mention being a brigadier general in the U.S.A.R. in his spare time. He has now been named the executive director and secretary of A.S.M.E. This will probably mean a move to New York City for Rogers, and we join in congratulating him on this well deserved honor and appointment.

See you next month. Send anything vital to me and I'll try to get it to our classmates. . . . Remember the Alumni Fund Drive and be thankful we have been able to help the current students enjoy many things that were not available to us.—**Michael Driscoll**, Box 1044, Nantucket, Mass. 02554

43

With deep sadness we report the untimely death of **Robert L. Lichten** on September 18, 1971, following an automobile accident near Dallas. Bob was director of advanced research for Bell Helicopter Co., where he had worked since 1948. He was immediate past president and chairman of the board of the American Helicopter Society and was considered one of the world's outstanding engineers in helicopter aviation. He was past president of the M.I.T. Club of Dallas, a member of the Educational Council for the past thirteen years, a past president of the Dallas Civil Liberties Union and a vice president of the Texas Civil Liberties Union. To quote from one of the letters sent to M.I.T. from people in Dallas, "This has been a stunning blow to Dallas—to all who loved, admired and respected this most unusual and wonderful man." Our class sent condolences to Sue Lichten and her three sons.

Last May our local papers carried an article about **Roland Grandjent**'s geodesic domes, and I lost it until now. His prototype model was 26 feet in diameter, constructed with triangles, using two-by-fours and exterior plywood. The article is most interesting. The homes are designed for vacation living, but I heard recently that they are expanding their operations to other types of uses for these unusual structures. If you are in the Granby, Conn., area, be sure to call Pete and see his domes.

Ray Frankel, who is president of Technological Investors Management Corp., (TIM), has been elected to the board of directors of D.P.F. Incorporated, one of the country's largest third party lessors of data processing equipment. . . . **Fumio Yagi** wrote that he is presently group head of systems analysis at Grumman Aerospace Corp. Both he and his wife are life masters of the American Contract Bridge League. . . . Since "new news" is a bit scarce this month, we've dredged up a bit of "old news" that somehow never got published! So, just sit back and make believe it's this time last year! With apologies to all about to be mentioned.

Edmund R. Swanberg was installed as a trustee of the United Presbyterian Foundation by J. Howard Pew, '03, President. Ned was elected as a Foundation trustee by the 182nd General Assembly, the denomination's highest governing body. An active Presbyterian layman, he was one of the founding members of the First Presbyterian Church of New Canaan, Conn. Our well-known classmate is a partner and vice president of Scudder, Stevens and Clark in New York City. This is a mighty fine honor, Ned, and my apologies for the delayed announcement.

Another clipping told us that **Allyn W. Kimball,** Dean of the Faculty at Johns Hopkins University, Baltimore, Md., was to return to full-time teaching and research there in July, 1970 . . . **Stanley Proctor** wrote a back-of-the-envelope report, "The A.O.C. Conference proved that trust and patience will go a long way toward a bright future—you guys are great!" Gee, Stan, thanks a lot! Are we considered Alumni Officers? . . . **Leo A. Fitzpatrick** sent in a clipping from the September 1970 issue of *Diesel and Gas Turbine Progress* in which **Warren L. Knauer**'s name was mentioned. Warren had just been promoted to director of underhood and industrial products operations in the Automotive Products Division of Motorola Inc. I hope I got all that right, friends! The article mentions that "The Automotive Products Division has established a very substantial beachhead in new product areas. . . ." Perhaps you'd like to establish a beachhead with the Secretariat here, Warren, and tell us more! . . . **Robert H. Handler** reported from Mexico in 1970: "Now that two kids are married and the third is a sophomore at University of Kentucky, Marie and I are living, working, playing lots of golf and travelling in Mexico City." Bob added that he is general director of an R.C.A. affiliate down there south of the border. If you send us a current report, Bob, we'll put it in the hot-news department!

Bernard S. Reckseit reported a year ago "have sold my business (D.L.M. Equipment Corp.) and am now operating as a consultant. Am doing machine design, mechanizing operations and assembly lines. . . . also general business consulting and methods engineering." By now, Reg, you may have added a few more business lines. . . . An article in *Science News* included **Edward N. Lorenz**'s prediction from M.I.T. that "By the mid-1980's atmospheric scientists should be able to reproduce an ice age in a computer. Such an achievement would be a significant extension of the work in numerical modeling of the atmosphere and of the ocean circulation now going on in several laboratories. In these techniques mathematical equations are used to simulate the behavior of the fluid envelopes."

One item of recent vintage: **George Feick,** formerly with Arthur D. Little, joined J.B.F. Scientific Corp. of Burlington, Mass., about July 1, 1971. During a recent visit here with his wife, George told me that this company specializes in the development and manufacture of water-related equipment. Over the years J.B.F. Scientific Corp. has developed oil skimming equipment, oceanographic instrumentation, sonar systems, and noise and vibration equipment. It is also conducting research under contract on stream and river aeration and on techniques to neutralize mercury pollution in sediments. Good luck, George, on your new endeavors—it's about time you came across with some news! Once in 28 years isn't asking too much now, is it? A few others fit this category!

Well, there you have it—the news of 1970 mainly! This year we'll take 1971 and report on Around the World with Feingold and Kelly. So send in *your* news and spare yourself from ours. Happy New Year!—**Richard M. Feingold,** Secretary, 266 Pearl St., Hartford, Conn. 06103; **Jack Kelly,** Associate Secretary, 34 Scudder Rd., Westfield, N.J. 07090

47

Trust that the New Year finds all happy, well and making great plans for 1972. Be sure that these plans include our 25th reunion at the Institute in June.

Received a very nice note from **Scott Hoehn** who plans to attend the reunion and asks for specific dates and times. Perhaps I have misplaced some mail but I don't recall as yet receiving any such material from Arnold Judsen. I trust that it will be forthcoming shortly. Scott has been in business for 18 years in Miami, Fla. He is secretary of the Scott Smith Air Conditioning Co. In conjunction with this work he is on radio and now TV for an hour each month answering questions on the subject of air conditioning. During the programs M.I.T.

normally gets a plug as Scott's appreciation of the Institute. He is very active in the Toastmasters Group in Coral Gables and encloses one of their latest bulletins which includes his picture which unfortunately will not reproduce. It also includes an "Open Letter to a Teenager" which is a bit long to reprint but we can offer a few paragraphs: *"Always we hear the plaintive cry of the teenagers: What Can We Do? Where Can We Go? The Answer Is—Go Home!* Hang the storm windows, paint the woodwork, rake the leaves, mow the lawn. Shovel the walk. Wash the car. Learn to scrub some floors. Repair the sink. Build a boat. Get a job!

"Help the Minister, Priest or Rabbi, the Red Cross, the Salvation Army. . . . Visit the sick. Assist the poor. Study your lessons. And then when you are through . . . and not too tired . . . read a book.

"Your parents do not *owe* you entertainment. Your village does not *owe* you recreation facilities. The world does not *owe* you a thing. *You owe the world something.* You owe it your time and energy and your talents so that no one will be at war or in poverty, or sick, or lonely again.

"In plain simple words: GROW UP! Quit being a cry-baby, get out of your dream world; develop a backbone, not a wishbone, and start acting like a man or lady." Thanks for the letter Scott—will look forward to seeing you in Cambridge in June.

From the clipping services we note that **Bob Kingston** recently gave a paper titled "Remote Heterodyne Detection of Gaseous Pollutants with Tunable Lasers" at the joint conference on sensing of environmental pollutants. The paper is concerned with smokestack effluent and I note that Bob has just moved from the M.I.T. lab in Lexington, Mass., to Youngstown, Ohio. I am not quite sure how to put it but I seriously doubt that in his new location Bob will need lasers to check on stack effluent. Maybe Bob can enlighten us on his new location and work. Drop us a line.—**Dick O'Donnell,** Secretary, 28516 Lincoln Rd., Bay Village, Ohio 44140

48

Members of the Class of 1948 who registered to attend the inauguration of M.I.T.'s new president were as follows: from Massachusetts, Fred Bailey, Lexington; Robert Bliss, Wenham; Ken Brock, Medfield; Dr. Walter Kolton, Boston; Dr. John Little, Lincoln; Peter Richardson, Cambridge; Graham Sterling, Wellesley Hills; and Backman Wong, Wayland. From out of state there were three members: Denman McNear, Kentfield, Calif., James Rattray, Springfield, Mo., and William Bangser, Westport, Conn.

George Wayne writes a newsy letter. He recently attended a meeting of the South Florida M.I.T. Club; **Russ Law** is president of the group. George has made a move to what sounds like the ideal homesite, "cars out front, boat at the back, and pool midway between." His new address is 6925 Sunrise Court, Coral Gables, Fla. Look out for company, George! . . . Recently married: **Joseph V. Yance** to Janet B. Peters, at the M.I.T. chapel. . . . **Ployer P. Hill** is heading for Europe and a tour with Hq. U.S. Air Forces Europe in Wiesbaden. . . . **Philip M. Lally** has two sons in college, Steve a senior at Southern Methodist and James a freshman at the University of California, Santa Cruz. . . . **Waller C. Moore** is now a Captain, U.S.N. (Ret), and is teaching math at Virginia Beach Campus, Virginia Community Colleges.

Ed Kosower is a professor of chemistry at the State University of New York. His wife, Nechama, is an associate professor of medicine at Albert Einstein College of Medicine. They have two children, David 9, and Daria 6. Ed has published numerous articles and two books, much of the work in collaboration with his wife.

Richard C. Berry was recently elected Chairman of the Regional Advisory Council for the newly established Quinebaug Valley Community College. For several years Dick has been head of Research and Development at Rogers Corp. . . . **William H. Brauer** was elected to a second four-year term on the Board of Control, St. Paul's College, Concordia, Mo. Brauer Supply Co. recently completed a move into new 60,000 sq. ft. headquarters in St. Louis.

A brief line on the back of **Ed Kratovil's** Alumni Fund envelope sounds a good positive note; "looking forward to our 25th in 1973." Let's hear that from more of you fellows! . . . **Norman H. Kreisman** wrote a more in-depth letter concerning his recent decision to resign as senior vice president of Responsive Environments and work full-time this year in the presidential campaign of Senator Henry M. Jackson. "Anyone who understands his (Jackson's) track record and has supported new technology and continuing development of our engineering, scientific and managerial manpower can understand the kinds of concerns that we all have today and why we can look to a man like 'Scoop' Jackson." Norman will be travelling around the country to gather support for Scoop Jackson's campaign, and hopes to call on many of his classmates.—**S. Martin Billett,** Secretary, 16 Greenwood Ave. Barrington, R.I. 02806

49

These class notes come close on the heels of last month, as far as my contribution is concerned. The result is a shorter than usual column with only a few items, mostly from Alumni Fund envelopes.

William E. Dennis reports that he is now Chief, Operations Division, Second District, U.S. Coast Guard, St. Louis, Mo. I must say, Bill, that this address confronts my stereotype that the Coast Guard belongs on the briny deep. I tend to forget about inland waterways, important as they are to our nation. . . . **Denny Kalette** is now business administrator, Pomfret School, Pomfret, Conn. . . . **Fred W. Reusswig** reports "On April 1, began new assignment as head of operations division at Stanley Consultants. First six months have been exciting and challenging. . . . Heard from **Bob Grigg's** family and **Maury Lynch** recently that all is well with them. . . . on the family front, daughter Pat, married in August, to complete undergraduate work this year at Iowa State; son Mike returns from air force service in January to resume college; son Dave a sophomore at University of Iowa; daughter Cathy a sophomore in high school." . . . Finally, **Harold Proctor** has organized a new company, Gabriel Electronics, Inc., to purchase a division of his former employer, Maremont Corp. Harold holds the offices of president and treasurer. Gabriel designs and manufactures microwave communication antennas. A new plant is under construction in Scarborough, Maine.

A report as of October 5, lists the following 1949'ers as registrants for the President's Inauguration: Anatol Bigus, Bill Edgerly, Len Newton, Kemon Taschioglou, Paul Weamer, and Warren Barr. Graduate attendees from the class: Chemical Engineering, Raymond Baddour; Naval Construction, Dean Horn; Physics, Benjamin Lax. . . . Gulf Oil Corporation reports that **Wayne P. Warlick** has been named general manager of Gulf's Computer Sciences, Inc., a wholly-owned subsidiary. In this role, he will be responsible for the marketing of the company's marketable computer time, software, computer systems and related capabilities.

Best wishes for the coming year to all in the Class of 1949. As Bob and Ray used to say, "write if you get work."—**Frank T. Hulswit,** Secretary, 77 Temple Rd., Concord, Mass. 01742

50

William L. Carey's new appointment to operations planning manager of the Portland General Electric Co., in Portland, Oregon, was effective in September of 1971. He will report directly to the President of Portland General Electric. . . . **Jim Blackard** reports that his wife and two oldest children are full-time students at the University of Washington. His two youngest children are in grade school. All in all, they tend to keep Jim on his toes. His job takes him up and down the coast from San Diego to Nome. Jim would enjoy meeting any old friends who live in his area. . . . **Raymond G. Hawes** tells us that he is presently the manufacturing engineering manager of the Fastener Division, U.S.M. Corp., Shelton, Conn. Visited sister plant in Birmingham, England, in January, hitting London for sight-seeing on two weekends. Ray is also the chairman of Industrial Fastener Institute, Division I, Blind Rivets Technical Committee. He is married with two boys, 16 and 13, who think only of "wheels," and a girl 10. . . . Thomas R. Eggert joined Huskin and Co., Denver, Colo., in March of 1971. He is involved in forming real estate group partnerships in Colorado. Tom's family enjoys Colorado and is looking forward to the ski season.—**John T. McKenna, Jr.,** 2 Francis Kelly Rd., Bedford, Mass.

52

Dick Lacey writes a sobering letter from

Palo Alto. "My friend, colleague and classmate **Joseph H. Holloway** died Saturday evening, September 25, 1971, at the Hoover Pavilion of Stanford University Hospital. He had been suffering from a brain tumor. Joe was from Shaker Heights, Ohio, received a B. A. from the College of Wooster and an S. B. from M.I.T. in 1952, and a Ph.D. in physics from M.I.T. in 1956.

After leaving school, he went to National Company to work on the development of cesium beam atomic frequency standards, the field that became his career thereafter. In 1960 he joined the Bomac Laboratories Division of Varian Associates where he was the principal designer of a series of cesium beam tubes that find widespread use in precision timekeeping and frequency control applications. In 1967 the cesium beam tube operation was acquired by Hewlett-Packard Company, and with them he developed a very small beam tube intended for aircraft collision avoidance systems.

He had been living recently in Saratoga, Calif. He leaves his wife, Nancy, a son and daughter, his parents and a sister. I knew him to be a diligent, creative, considerate man, universally liked and respected by those who knew him. It is worth remarking that the nation's time and its frequency standard are kept with instruments in whose design he had a major role.

Also from Dick comes a clipping from the *Palo Alto Times* describing the work of Dr. **Zoltan Lucas,** assistant professor of surgery at Stanford Medical Center. Dr. Lucas is involved in work on kidney transplants. Investigating and using techniques of medication for suppressing the body's reaction to foreign tissue is his contribution. . . . **Leith Holloway** writes that he has spent some of his free time the past year working with Princeton groups involved in protecting and improving the environment. . . **Harry Wenning** has his own architects' office in Hastings on Hudson and is doing all types of work. . . . **Clifford M. Sayre, Jr.,** is now technical superintendent of DuPont's Pontchartrain Works near New Orleans. . . . **Philip Thiel** is continuing and expanding the development of his work on a time-based discursive notation for the description of environmental-contingent experiences and for experienciable environments.

If you like jams and jellies, you will no doubt have been reminded of **Leonard Polaner** on every supermarket trip. Lenny now writes that the past few years have been full for him. His family now numbers four Children, ages 9 months, 5, 7, and 9 years. The oldest is a daughter; the others are all sons. He is president of M. Polaner and Son, the family-owned preserve, jelly and specialty food manufacturer. Under Lenny's guidance the firm moved into a new 53,000 square foot plant in Roseland, N.J., in 1968. Also, he has developed new product lines that have helped the company to grow and make full use of the new facility.

Charles G. Fletcher has been appointed to the post of president and general manager of Jerguson Gage and Valve Co., Burlington, Mass., a manufacturer of liquid level gages and valves for power and process applications. Previously Mr. Fletcher was vice president and general manager of Jerguson. He lives with his wife, Carol, and four children in Winchester, Mass. . . . **Frank T. Wheby** has been appointed an associate of Harza Engineering Co., Chicago. He is also head of the firm's Underground Projects Division where his major present assignment is design of part of the new subway system for Washington, D.C. Frank, his wife, Jude, and their two sons, Christopher 3, and Jonathan, 1 year, live in Evanston, Ill.

F. T. Wheby, '52

C. G. Fletcher, '52

L. Zuker, '55

Harold Tepper, executive vice president of Alliance Medical Industries, Inc., has been appointed building project coordinator for a new design for the Jewish Home for the Elderly of Fairfield County. Harold is secretary-treasurer of Fairfield County, Conn., M.I.T. Alumni Association. . . . **Frank C. Wilson** is senior research chemist in DuPont's Plastics Department. . . . **Harold T. McAleer** is manager of custom products at General Radio Co., and is responsible for marketing, design and manufacture of custom-tailored test systems. He is also publicity chairman for the 20th reunion of the Class of 1952. . . . **Donald Jaffe** writes that he has been active in labor negotiations with teachers in his work on the East Penn School Board (Allentown, Pa.). September 30 was the strike deadline! Donald's oldest daughter, Nancy, has started her first year at Wellesley College and is hoping to get into some classes at M.I.T. next year. His other four children are in local schools, one in high, one in junior high and two in grade school.

Don't forget June 2, 1972! Class 20th reunion at Edgartown, Martha's Vineyard. See you *all* there.—**Arthur S. Turner,** Secretary, 175 Lowell St., Carlisle, Mass. 01741

55

As the days are rather short at this time of year, I shall try to minimize your electric bill by keeping the column short. Of course, if you send me some news, we could all splurge another kilowatt.

Samuel C. Goldman is now the chief engineer for all domestic nuclear operations of the Picker Corp. He has also co-authored a series of papers in the *IEEE Nuclear Science Transactions* on the subject of computer processing of isotopic images. About a year ago Sandy, his wife Mary Glenn, and daughter Abigail abandoned apartment living for a home in a rural setting in Bethany, Conn. At last telling, the Goldmans were concentrating on the production of ceramic coffee cups and children. (No, not ceramic children).

Receiving Certificates of Appreciation last fall for their efforts on behalf of the 1971 M.I.T. Alumni Fund were **David K. Easlick,** leadership gift chairman for Indiana, and Colonel **Leonard R. Sugerman,** Alamogordo regional chairman. **Peter Toohy** has been nominated for the M.I.T. Alumni Advisory Council.

Alan Glueck wrote an article for the July 1971 issue of *Chem Tech,* arguing that computers are nice, but it helps to use your mind as a buffer stage. He is president of Chemical Technology Corp., and does consulting in applied chemistry, data mangement, and medicine. . . . **Lee Zuker** has been named general manager of Aircraft Radio Corp., the avionics-producing division of Cessna Aircraft Co., located in Boonton, N.J. Lee, who was previously a division manager with Allis-Chalmers Corp., holds a commercial pilot's license and has logged over 2,000 hours of flying in various military and commercial aircraft.

On the academic scene, **Charles Ladd,** who is a professor of civil engineering at M.I.T., headed a special summer program on soft ground construction. He found the program to be a lot of hard but rewarding work, and that it attracted participants from eight nations. . . . At Duke University, **Olaf Stackelberg** has been appointed managing editor of the *Duke Mathematical Journal.* His wife Cora is teaching mathematics at Durham Technical Institute. . . . During the past semester, **Martin L. Shooman** has been a visiting associate professor in the Department of Electrical Engineering at M.I.T.

A note from Mona Fuzzer informs us that Oswald apparently is being incarcerated in a mideast jail due to some misunderstanding over illegal agricultural products. Very little information is available, and I must add that I haven't heard from you, either.—**Allan C. Schell,** Secretary, 19 Wedgemere Ave., Winchester, Mass. 01890

56

Oops—missed you all last month, but here is a continuation of tidbits from the reunion. Just for the record, here are some more of the banquet awards. . . . *Bird*—Of course, Nelo and Eva Sehler were vying for the longest travel distance award only to be nosed out by Nick

Biever who made it in from Luxembourg. . . . *Bicycle*—**John Morefield** and Mary Anne, for being first out to the bicycles each morning. . . . *Golf*—**Tom Hoffman** and Dianne had the best score in 18 holes (and were probably the only ones to play 18 holes). . . . *Runner*—**Charlie Joyce**—He got hit by a cab in Paris about six months before the reunion and was just getting back his street legs. He had just gotten out of the cast. . . . *Winner* or Champion—**Ron Kiaer** and Karen who went fishing at the reunion, caught two and had the hotel prepare them for their meal. . . . *Wrestler*—**Dave Shefrin** and Roberta Schwartz who were soon to be married.

As usual, one of the interesting features of the reunion is learning more about our classmates' current occupations. Enclosed are a few vignettes: **Harold Friedman,** Manager of the Electronics Department of Kurt Orban Co., an import-export firm. . . . **Jim Hamblet,** President, Foundry Technology, Inc.—sells metal and does foundry work. . . . **Jack Hofmann,** specialist in evaluating worldwide liquified natural gas projects for Standard Oil of New Jersey. . . . **Harvey Levine,** Manager, Turnkey Planning for Research-Cottrell—specialized in air and thermal pollution control equipment . . . **Jack Rosenfeld** brought his pretty Danish bride . . . Nelo Sehler, managing director of Acetogen Gas de Venezuela which manufactures and sells gas for metal-working . . . Dr. **Wolf Vieth** has received recognition as chairman of a newly renamed "department of chemical and biochemical engineering" at Rutgers University, the first department in the U.S. to adopt such a title. This curriculum recognizes the dual function and multidisciplinary approach to chemical engineering. In the three years Wolf has been at Rutgers, enrollment in this course has increased from four to 104 students, grants have doubled, and several patent applications have been filed, two of which are under commercial development.

According to our reunion questionnaire, 33 of those who replied are involved in teaching. . . . Among those at the reunion were **Tom Cleaver,** who is a professor of economics at Villanova, and **Max Plager,** a mathematics professor at Roosevelt University in Chicago. Many of the wives have been teachers, and a number are now working in positions ranging from nursery school to an M.I.T. professor of German. The diversity of specialties that the wives teach includes music lessons, gourmet cooking, and making beaded flowers.—Cosecretaries: **Bruce B. Bredehoft,** 3 Knollwood Dr., Dover, Mass. 02030; **Mrs. Lloyd Gilson,** 35 Partridge Rd., Lexington, Mass. 02173

57

Happy New Year. Here is some of last year's news. **Pete Richards** dropped us this note: "I am on leave from the University of Kansas for 1971-1972 at Sandia Laboratories, Albuquerque. Since my last communication too many years ago we have a new daughter born in 1968, for a total of three children. Also, I was promoted to Professor of Physics in 1969." . . . **Mrs. Richard Rosenblatt** is now teaching mathematics at Horace Greeley High School in Chappagua, New York. . . . From **Dominick Fortunato** came this report: "The situation with us is pretty much the same as last time I wrote. Couple of new items: my wife Loreta obtained her license as a Registered Nurse in N.J. and has gone back to work in a hospital, on part-time basis. Now I'm taking a review course for the exam to obtain a licence as a registered professional engineer in N.J. I've been pulling out some old books I haven't looked at since leaving Tech."

That's all for '57. I'm waiting for those holiday greetings crammed with printable and quotable news. Before closing I would like to add a note to any '56ers who might glance at this column—my brother, John Morefield, had a tough bout with cancer but now is on the mend. He was fortunate to get surgery and treatment in time.—**Fred L. Morefield,** Secretary, Tiirasaarentie 17, Helsinki, Finland

58

Happy New Year and, for many of you, happy job change. **Richard Tromel** describes his recent change: "This year I left the aerospace industry and moved from Canoga Park, Calif., to Troy, Mich. While the family has been getting used to Michigan weather, I have been learning the differences between R&D in the rocket engine and the truck component business." . . . For those who may be trying to make a change, **Harvey Rosenfield** writes that he has gone into his own "personnel placement business specializing in full-time and part-time placement for the data processing industry and related fields."

In attendance at the 1971 Mexico City M.I.T. Club Fiesta was **Jose Luis Cubria Palma.** . . . **Keith Dawber** will be on refresher leave in Australia, primarily in Melbourne, during 1972-73. . . . Among our recent degree gatherers was **Gregory Hood** who obtained his Ph.D. in physics from Boston University this past June. . . . **Peter Lawes** is an assistant professor of mathematics at Northern Illinois University and recently attended an advanced science seminar at Bowdoin College on the subject of combinatorial theory. Until 1970, Peter had been an assistant professor at Oakland University in Rochester, Mich. He and his wife, Patricia, are now residing in DeKalb, Ill. . . . **Dante DiFranco** writes that they now have two children, Ross Compton and Angelia Maria. . . . **McClaran Jcrdan** is currently serving as vice president of the M.I.T. Club of Oklahoma and has also been elected treasurer of the Oklahoma City Chapter of the Society for Advancement of Management. . . . At the autumn meeting of the National Academy of Sciences in Washington, D.C., **David Buhl** presented a paper describing the molecular astronomy work being conducted at the National Radio Astronomy Laboratory.—**Michael E. Brose,** 199 Sudbury Rd., Concord, Mass.; **Antonia D. Schuman,** 22400 Napa St., Canoga Park, Calif.

60

Here we go again. It's old Uncle Mike (Padlipsky), paying off another debt. This time, it's a debt of Honor. (Hold the snickers, please.) Y'see, last Thursday I was off on a consulting expedition—to the toy department of the Porter Sq. Gilchrist's basement, where I was being a technical advisor in charge of giving opinions on birthday presents for friend's nephews, and on the way out happened to spot an ad for a sale lot of suits. So I picked up this four/five piece tweed (domestic) number (contrasting slacks, reversible vest sort of thing), which was just what I wanted to wear Friday. Naturally, for such vital functions as an emergency cuffectomy on a Thursday night the only thing to do was to call the World's Greatest Costume Expert. And when I told Linda that I probably owed her another Class Notes, she allowed as how she hadn't done any for quite a spell . . . so here I am. (Oh yeah, the reason why I was able to buy the suit is that I've moved, and now have considerably more closet space; in the old place, I couldn't have committed matrimony or even had a longish term guest with anybody who owned more than two dresses. At least in the new place, I *could*. . . .) (Just for completeness, a second second thought: new place is still in Cambridge; I'm still at Project MAC.)

Linda asks me to add that her writing has been limited to a book, a paper, and a dissertation in recent months. Regardless of that, true though it be, I think I'll start with the following letter from **Peter M. Silverberg:** "Dear Linda: If the class secretary is not Linda Sprague please understand that I am out of touch. I have some interesting news about myself. My stay at Pratt and Whitney Aircraft Division lasted six years, 1965-1971. During 1970 the general softness in Aerospace began to show up in secondary effects; i.e., no new hiring, no raises, no promotions and constant admonitions of the need for attrition. While in no danger of layoff I was getting bored of the increasing clerical load of a once exciting job. Through an employment agency I made a connection and am now working as an engineer for General Electric—Large Steam Turbine and Generator Division, Materials and Process Laboratory, Schenectady, N.Y. Ellie and I have bought a brand new house and the kids are now 4 (Lynn) and 7 (Lee), making even empty space useful."

One other letter to deal with before getting on to the Lines from the Backs of Envelopes Department, this from a class officer, **Burgess Rhodes.** "In my First general soliciation as Class Agent, I made an indirect promise to post the answer to a problem in alumni giving in our class column of the *Technology Review.* In order to fulfill that promise and to report on my activities since leaving M.I.T. ten years ago, let me simply list a number of facts. I will leave it up to you to assemble them in an appropriate format. [Would I argue with a good thing?—M.A.P.]

"Entered the Graduate School of Mathematics at Lehigh immediately after

finishing at M.I.T; completed an M.S. and a Ph.D. in mathematics; for most of my years at Lehigh I taught full time, and, upon receiving my degree, I took a position as operations analyst/mathematician with Daniel H. Wagner, Associates in Paili, Pa.; married the former Audrey Rood (sister of an M.I.T. undergraduate friend); two children, Sandy, age 8 (student of jazz ballet) and Brian, age 5 (professional frog hunter); for relaxation, the whole family enjoys camping.

"Recently I assumed the very rewarding role of Class Agent—and classmates, "$22.22, give or take a penny," is the answer." Whoops, I almost overlooked another letter, this from **Rick Faber:** "I would like to offer my exciting chapter to the suspense-laden saga of '60. I am happy to report my promotion to Associate Professor of Mathematics at Boston College, effective September, 1971."

And now on to L. from the B. of E.'s (which are, of Alumni Fund Pledge E.'s, and for which, thanks). Actually, the first one will probably get me into more trouble, but I don't have the heart to paraphrase: "Hi Linda—Every time I read the *Review* I admire your devotion to duty and resolve to communicate. So now resolve is transformed into action. I received an M.B.A. from the University of Connecticut last June (1970) and I'm presently with Pratt and Whitney Aircraft, working on advanced control systems for fuel cell power plants. It's pleasantly challenging and the recent aerospace funding cutbacks and an 'exciting new dimension' to this challenge. I've been back to the Tech campus a couple of times in the past year looking for familiar faces and found mainly unfamiliar buildings instead. Most of the familiar faces don't seem to write to you either and I wish they would. (That's a hint to them.) **Paul F. Berg."** . . . and from D. R. Waldman, "After four years postdoctoral work at Harvard (and 15 in Cambridge), have emigrated to central New Jersey. Present position, Associate Professor, Department of Geological and Geophysical Sciences, Princeton University." . . . From **Jason L. Speyer:** "Received Ph.D. in applied mathematics in March, 1968, from Harvard. Am married to the former Barbara J. Sachs. Have a one-year-old son, Gil Avner, who will have a sibling in September. Am working at Draper Lab. Live in Winchester."

Lawrence O. Booth is with Booth and Somebody who starts with an "N" whose name I can't read Architects, 109 W. Harvard St., Chicago, Ill. Cheer up, if I could've read the name I wouldn't've plugged the address. . . . And another architect closer to home is **Bill Bisson,** who writes, "Currently ekeing my way thru pre-registered-architectural apprenticeship. Good fun at times. Horrendously boring at others. Not lucrative enough to be worthy of mention. All in the game." . . . And architecture must remind us of Art (or so most of my architect friends would have it), and that reminds us that at the time she wrote on the back of the envelope **Susan Schur** was having an exhibit of some of her recent paintings and drawings at the M.I.T. Faculty Club. Matter of fact, I saw and enjoyed it, but it was a while ago as I recall.

Now how about a paragraph on various kinds of analysts. **William J. Nicholson** joined Potlatch Forests in San Francisco as a planning analyst in the corporate planning group in May, and has settled in Ross, "a small town about fifteen miles north of San Francisco." . . . **Shel Epstein** says, "I'm still analyzing new business opportunities at Brunswick. My wife, Suzy—**Sam Latt**'s sister—was promoted to Assistant Professor at Barat College in Lake Forest. Sam is on the verge of getting a Ph.D. in biochemistry at Harvard. Saw **Milt Weiner** several months ago in Cambridge. He's getting married. **Alan Shalleck** is a vice president at Leasco Data Processing and **Mark Dichter** is making movies in N.Y.C." . . . And from **Robert L. Mullen,** "Have recently moved to Massachusetts where I am now working on production control systems as a senior systems analyst for American Optical Corp., in Southbridge. Would like to hear from classmates in the state, at Old Village Road, Sturbridge, Mass. 01966."

Two more envelopes: from **Bruce Silberg,** "Am presently enrolled as a master's degree candidate at the University of Massachusetts, in computer science, a science which did not formally exist in the late '50s, Word is that *Voo Doo* has folded. A shame, because humor helped keep your head 'above water'." . . . Then, last, and certainly least, is an envelope which simply says "Hi, Linda." and is signed by one **Christopher R. Sprague.**

Finally, a quick skim through the clippings. **Charles McCallum,** as chairman of the Metro-Services Committee of the Grand Rapids Chamber of Commerce, spoke on "C. of C. Home Rule Project" before the Grand Rapids Engineers' Club. . . . The Maryland Academy of Sciences awarded a Distinguished Young Scientist certificate to **Calvin S. Koonce** (National Bureau of Standards). . . . **Harry C. Wolf, 3rd,** President of Wolf Associates Architects, received a National A.I.A. Honor Award, "the nations' highest professional recognition for architectural excellence." . . . **Raymond R. Ambrogi** was named plant manager at the North Bergen, N. J., Corning Glass Works plant. . . . According to the *Harvard Business School Bulletin,* **"Mark Pratt** has been named sales manager—aromatic chemicals at Enjay. His other activities include fixing up a 48-year-old house in Hastings-on-Hudson, helping Marysue with the three children, the Riverview Manor Associates, and the Volunteer Fire Department." . . . **M. C. Porter** is author of a five-part series on Membrane Ultrafiltration in *Chem Tech.* . . . The White House has appointed **Ray Waldmann** as Staff Assistant to the President for Domestic Policy Planning. . . . And the one I've saved for last: **Warren Van Genderen** is president of I.S.I., San Francisco, manager of $600 million in mutual funds and $500 million in insurance investments.

Well, my back tells me that I've been hunched over the typewriter quite long enough—so Cheers for now, and please do write a lot of letters insisting that I not be allowed to do any more Class Notes to **Linda G. Sprague,** 10 Acorn St., Cambridge, Mass. 02139

62

Should auld acquaintance be forgot and never brought to mind—oh mighty Class of '62 where has flown the time? As the bells ring in the new year, 1972 brings to mind that exactly ten years from this June the fruits of our labors were recognized and we gratefully acknowledged the long-sought degrees that were bestowed upon us. Many changes have transpired since that year—most 1962 women seemed content to play the role of housewife or underpaid employee or maybe they just accepted it. Today women's libbers seem to dominate every phase of American life, demanding equality and even though the family unit seems to be slowly disintegrating, through the high rise in divorce (now, of course, dissolution), cohabitation, organized mate-swapping, we still find the majority of Americans striving to preserve the warmth and closeness that only committed relationships can provide. . . . Typifying the family unit, **Barry Roach** tells us that his wife Kate has retired from teaching, that they've recently moved to a new home in Portola Valley, of their newest and most special addition, a belgian sheepdog named Crockett and his election to the partnership in McKinsey and Co. . . . New Papa **Jeremy Goldberg** proudly announces newborn cherub Devra Ilene and she in turn discloses that her Daddy was elected to third vice president of Titereth Israel Synagogue. . . . Also confirming the capabilities of the 1962 men is **Philip Nelson,** father of two little sons: Alex born last June 1 and Erik, age two.

These past ten years have produced remarkable accomplishments in the field of medicine, especially in the realm of organ transplants, birth control and recently a serum that was developed that kills two types of cancer viruses in hamsters and rats and is a potential cure for human cancer. . . . Serving for the next two years as a Cardiology Fellow at the Columbia Presbyterian Medical Center is **Melvin Weiss** who was formerly a fellow of the New York Heart Association. . . . Dr. **Anthony J. J. Rourke, Jr.** has served as Special Assistant to Director of Clinical Center National Institute of Health since August of 1970.

There are, of course, some things which haven't changed a bit, such as our presence in Indochina and the perennial bickerings at the U.N. The military, though has slightly altered its image by becoming a smidge more tolerable and even showing some understanding of the human character, although the lack of support in and purpose of the everlingering war has slowly forced these modifications. . . . We have heard from **Donald W. Horner** who was promoted to Lieutenant Commander of the U.S. Navy in March last year. . . . No one has to tell us of the growing inflationary problems; each one of us has had our pockets burned to some degree—wages may have been frozen but not promotions and we have word from **James G. Brandely** that he has been named manager of research of the Sun Oil Co., in Philadelphia. . . . Since September of '69, **Rurik**

Halaby has been an associate in the investment banking department at Paine Webber in N.Y. . . . **Winn F. Martin** has recently taken the position of systems manager for the mobile housing group of Boise Cascade Corp., besides marrying the former Miss Patricia Van Wezel in March of 1971.

Perhaps one of the most changing systems in the United States is education. Students have incorporated the first amendment into their way of life, demanding rights through protest while in comparison, ours was an era of acceptance and tranquility. . . . **Harold Metcalf** is presently teaching introductory physics (recall 8.01 and 8.02 anyone?) and offers true empathy to his Professors Kingard and Kranshaar by acknowledging that "they really earned their pay in 1958-59!" . . . We congratulate **Dushan Mitrovich** who received his Ph.D. from the Graduate School of Arts and Sciences at Harvard University last June.

The field of technology has offered some of the most exciting achievements; outstanding is the moon walk and the orbiting satellites which transmit television from all points in the world. . . . also characteristic of the changing times is the "computer syndrome" that grows more prevalent with the adaptation of the computer into all phases of business. . . . **Alan Kotvic,** Consulting Engineer at Digital in Maynard, Mass., has recently completed the design of the latest PDP-10 processor. . . . **J. W. Devanney** analyzed the following question for the American Chemical Society's fall meeting in Washington, D.C.: "Under what conditions would a type A fish protein concentrate be an ingredient in an economically efficient protein supplementation program for a developing country?" all of this being incomprehensible to me, I conclude—"It sounds a little fishy to me!"—**Gerald L. Katell** 122 North Maple Dr., Beverly Hills, Calif.

64

This month has produced three Class Heroes. One of these is **Pete Angevine,** who wrote me the following comment from Ridgefield, Conn.: "You say you've been practicing law for four years and really enjoying it. Well, when we bought our house, we got a bill from our lawyer that tells me why you enjoy it so much!" Ah, if only all us lawyers could send our bills to Pete. . . . **Jack Downie** writes that he and his wife Darlene have moved to Asheville, N.C., where he and another former co-employee of DuPont have established their own corporation called Asheville Plastic Services, Inc. The corporation is engaged in the fabrication of thermoplastic and thermosetting materials by the injection molding process. Jack hopes to service the southeastern industrial market with expansion to national accounts. . . . **David Saul** and his wife Susan have announced the birth of Michael Adam Saul of October 27, 1971, who weighed in at 7 pounds, 9 ounces.

As for news of others, **Charles Abzug** has completed his Ph.D. in physiology at New York Medical College and has now started postdoctoral work at Rockefeller University in the field of the vestibular system. . . . **David Hoover,** Executive Director of the Framingham, Mass., Redevelopment Authority, has been appointed as one of nine Loeb Fellows by the Harvard Graduate School of Design. This appointment will result in further education in the field of advanced environmental studies. . . . **Ned Block** is a post doctoral fellow in the M.I.T. psychology department, following his Ph.D. in philosophy from Harvard. . . . **Joe Boling** is working on his M.B.A. at University of Washington, where he is also teaching R.O.T.C. He and his wife Louis now have three children. . . . **Ed Casper** is teaching chemistry and health at Salesian High School in New Rochelle while his wife Gale is employed by Travelers Insurance Co. . . . **Bruce Crocker** is at Stanford Business School working on his M.B.A. He and his wife spent last summer in Boston where he was working for the Boston Consulting Group . . . **Bill Hoffman** is project engineer at Aerospace Systems, Inc., a corporation founded a year ago by himself and other M.I.T. alumni and staff. . . . **Robert Johnston** is chief resident in ophthalmology at West Haven Veterans Administration Hospital. He and his wife have two children. . . . **Alton Otis** has completed his course work toward a Ph.D. in computer science at the University of Illinois. He is now working as director of software development for Xebec Systems in Mountain View, Calif. . . . **Leonard Parsons** has co-authored an article in the May-June, 1971 issue of *Operations Research* and co-edited a book on *Marketing Models: Quantitative Applications*. . . . **John Rainier** and his wife had their second child, Kathryn Virginia, last April 26 . . . **Chris Ritz** is professor of computer science at Thomas More College in Covington, Ky.

Allison Russell received his Ph.D. at the University of Illinois and is now engaged in post doctoral work in the physics department at the University of British Columbia. . . . **Joshua Singer** is an assistant professor of physiology at the University of Massachusetts Medical School in Worcester. He received his Ph.D. in physiology at Harvard in June of 1970. . . . **Andy Silver** is an assistant professor of film at Brandeis University. . . . **George Sullivan** (Mike) is establishing a small business consulting practice in Palo Alto, Calif. During the past several years he has co-authored a NASA technical note on satellite attitude control systems, visited the Congo and Vietnam as an airborne army officer, and picked up an M.B.A. at Stanford. . . . **Gary Walpert** and his wife Ellen have moved to New York, where he has joined the patent law firm of Fish and Neave. Ellen is studying for her own law degree. That's the news this month. Let me hear from you.—**Ron Gilman,** 5209 Peg Lane, Memphis, Tenn. 38117

65

The column is thin again—I guess because the fall peak in alumni fund contributions (and envelopes) is over. If you don't send news, I can't report it. So once again, please write!

Dave Moran reports that he received his Ph.D. in hydrodynamics from University of Iowa last May. Dave is now working at the U.S. Naval Ship Research and Development Center in Carderock, Md. He says it's a civilian job and that they call him a naval architect. Dave and Susan now live in Rockville, Md. . . . **Edwin Kampmann** plans to finish his Ph.D. thesis in the next few months (perhaps by the time you read this). His topic is planning for solid waste post-collection management for an urban area. Ed is another of the outing activity-types (like your secretary) and has recently started leading trips for organizations out that way. . . . **Peter Klock** is still working on a Ph.D. at Johns Hopkins (biophysics) and says he is not trying to set a record for duration nor working toward tenure.

William Mogensen was married on November 7, 1970 to the former Kathleen Low in their hometown of Elizabeth, N.J. Bill is teaching and working on his Ph.D. in materials science at Rutgers. The Mogensens went to Hawaii on their honeymoon and stopped in California on their way back to visit **Bob Dausch.** Bob and his wife Mary are living in a new house in Fountain Valley (near L.A.) with their daughters Christine and Marianne. (Thanks to Bill for news of a classmate.) . . . In January, 1966, **George Herzlinger** married the former **Regina Elbinger** (also '65). Both Herzlingers received Ph.D.'s last summer—George in physics from M.I.T. and Regina in business from Harvard. George is now an instructor in physics at Tech and Regina an assistant professor at the Harvard Business School. Are there any other classmate marriages in our class?

Leo Lake was married to the former Mary Beth Rasey of St. Paul on June 19, 1971. John Currano was a groomsman. Leo is now finishing his thesis for a Ph.D. in physics at the University of Minnesota . . . Barbara and **Charles Rall** report the birth of a new son, Christopher James last February. Charles works for Bellcomm, Inc., and is doing Bell System research rather than space studies. . . . **Dick Bator** reports a lot of news this year. In December, 1970 he joined Azrex and last March was promoted to vice president. Also in March, Fran and Dick bought a garrison colonial house in Westford, Mass. On October 16, the Bators had their second son—Jeffrey Brooks Bator. All in all, an eventful year. . . . **Dave Crawford** is in Leeds, England working as a consultant to the English subsidiary of J. I. Case Co. Dave has been in Leeds since February 1971 and recommends working overseas as a great experience. . . . **Frank Mechura** is presently the Chicago district sales manager for the corrugated division of Continental Can Co. . . . The Reverend **Richard Armstrong** is doing research for the Harvard University Administration and teaching two courses at St. Anne's School in Arlington, Mass.

Bill Alves was nice enough to send a letter elaborating on his experiences on Mt. Ritter last June (reported in the October/November *Review*). Bill spent a month last summer vacationing in Alaska and the Yukon after he recovered from

his four days out in the snow and cold. He reports that his experience as a winter mountaineering leader for the M.I.T. Outing Club served him in good stead the first stormy night that he had to spend in a snow cave at 12,500 feet without a sleeping bag. After that he attributes his survival to a "naturally stubborn nature" that kept him plugging away for three days until he reached civilization. Bill returned to Mt. Ritter the first weekend in October intending to climb it solo by the same route and piece together what happened. However the first "winter" storm of the season preceded him by a few days and made the climb too risky, so he climbed neighboring Bonner Peak instead. Bill says he got good views of Ritter from Bonner but that the climb of Ritter will have to wait until this summer. (Thanks to Bill for spending the time to report his thoughts on the climb and his subsequent attempt.)

The MITRE complex is populated by a few more classmates these days. **Matt Mleziva** is working as a civilian for the Electronic Systems Division of the air force and has an office in the complex. . . . **Ed Burke** joined the technical staff of MITRE during the summer and has an office near mine. Ed is a leader in a variety of after-hours outdoor activities. The writing of this column (in early November) was interrupted when I went out to a Burke-organized game of soccer. Ed will probably be able to walk tomorrow (Monday) but I'm not sure I will.—**Steve Lipner,** Secretary, 3703 Stearns Hill Rd., Waltham, Mass. 02154

67

Our Fifth Reunion will be held during the weekend of June 2, 1972. I hope that many of you will plan to travel to Cambridge for this event. **Mike Zuteck** has news that is of special interest to sailing alumni. He went to Canada to sail in the Tornado Class at the C.O.R.K. (Canadian Olympic-training Regatta-Kingston) meet. He compiled a 4-2-1-1-1 record and won the class with a 2-1-1-1 record, fourth place being the throw-out. Mike found his four years on the Tech sailing team very helpful in tactics and light wind; the calculus of variations and optimization was useful in attaining optimum boatspeed. . . . **Alan Hausrath** sent the following letter: "On July 15 I defended my thesis at the Division of Applied Mathematics at Brown. Although I won't receive my piece of paper until next June, I officially became a Ph.D. on the date of the defense. On August 17 I married the former Miss Anne Stites of Pembroke College. I presently have an appointment as an assistant professor in the Department of Mathematics at University of Pittsburgh." . . . **Richard Cutler** received an M.A. degree in philosophy from New School for Social Research in New York City and is currently a teaching assistant for the Philosophy Department of Boston University.

Greg Wight married the former Miss Tamara Finlaw April 3, 1971. He has been promoted to Captain, U.S.A.F., and is still stationed at G.E. Engine Plant, Cincinnati. . . . Meredith and **Alan Dubin** are the proud parents of Elizabeth Gail, born June 1, 1970. The Dubins recently bought a home in Glastonbury, Conn.; Alan is still with United Aircraft Research Labs. . . . **George Starkschall** plans to complete work for his Ph.D. in chemical physics at Harvard by the end of this academic year. . . . **Bill Glock** married the former Miss Carol Kitchura of Floral Park, N.Y. The Glocks live in Great Neck and work for Sperry Systems Management, Carol as a computer programmer and Bill as an engineer. . . . **Robert Gann** received an M.B.A. from Northwestern in June, 1969, and has since been employed in the Management Science Division of Northern Trust Bank in Chicago. In December, 1969, he married Betsy Scott (Wellesley '69). . . . **Neil Steinmetz** completed medical school at Chicago and has returned to Boston where he is an intern at Beth Israel Hospital. He is looking forward to renewing friendships with classmates still in the Boston area. Neil writes that he saw **Eric Coe,** who is enjoying his internship in Pittsburgh.

Raymond Giglio writes: "I have left (escaped?) the aerospace industry and am working for an electric utility in Augusta, Maine. Most of my work is on pollution abatement and other environmental matters; I finally got a chance to do some actual work in this field. Marsha and I are spending all our spare time mountain climbing, backpacking, playing tennis, etc., and we are quite happy. Hope you are well." . . . **Douglas McCraith** received his M.S.E.E. from M.I.T. in June, 1970. He is working at Lincoln Laboratory in ambulatory health care delivery. . . . **Alan Hirsch** reports that he and Kenneth Dritz, '66, are still working at Argonne National Laboratory in systems analysis and programming. Alan has been measuring the performance of various computing systems, one of which may be acquired by Argonne. Ken and Alan spent 12 days in August on a canoe trip in Quetico Park, Ontario, "getting away from it all.". . . **Richard Haberman** finished his Ph.D. thesis in applied mathematics at M.I.T. last summer. He then spent three weeks driving across the country to University of Caifornia, San Diego, to accept a post-doctoral appointment as an assistant research geophysicist in the Institute of Geophysics and Planetary Physics located on the cliffs overlooking the beach in La Jolla. He will also be a lecturer in Department of Aerospace and Mechanical Engineering Sciences.—**Jim Swanson,** 508 Thompson Ave., Mountain View, Calif. 94040

68

We now have two Sc.D's in the Marcus family as I finished my thesis about a month and a half after Gail. We celebrated the occasion by going to Europe and have just returned after a seven-week trip. We bought a Saab 99 in Stockholm and drove about 4,500 miles visiting Oslo, Frankfurt, Bern, Geneva, Paris, Normandy, London, Brussels, Amsterdam, and Copenhagen. It was a great trip and our only problem was that it's a little chilly in northern Europe in October and November. However, it gets cold in Boston too, so we didn't let it bother us too much. While in Frankfurt we visited Joanne ('71) and **Art Cole** and their daughter Gwen who live in the small town of Braunschardt while Art is stationed at Rhine-Main A.F.B. He was recently promoted to captain and works odd hours supervising the loading and unloading of planes. It's not a very interesting job, but they really enjoy living in Germany on the local economy While in Bern we visited Alberic Muller (S.M.'71) and his family. Alberic showed us around Switzerland from one end to the other. Now that the trip is over we are awaiting employment. It looks almost definite that we will be in the Washington, D.C. area, however many details have yet to be arranged.

We are happy to report the marriage of **Margaret Eikrem** to Robert Keller (Ph.D.'70) on October 2, 1971 at La Canada, Calif. . . . Also in the Milestones category, Deborah and **Russel Silverman** report the birth of a boy, Aaron Joseph, on June 28, 1971. In August the family moved to Miami where Russel is assistant administrator of the Green Briar Nursing Center.

It seems like large numbers of classmates leave the environs of M.I.T. for a short trip up the river to the other school in Cambridge. This June Harvard awarded degrees to the following members of our class: **Ali Allawi**—M.B.A., **Ben Cox**—J.D., **Virginia Fano**—M.A.T., **Phillip May**—Ed.M., **Paul McCreary**—M.A.T., **Mike Rodburg**—J.D., **Clyde Rettig**—M.B.A., **Steve Swibel**—J.D., and **Tom Uribe-Mosquera**—M.B.A.

Dennis Noson writes that after a three-year interruption due to the draft he is again beginning graduate studies in oceanography, "this time with a wife and more wisdom to help me succeed. . . . **Bill Lamb** is working as a research associate in ocean engineering. . . . **Don Batchelor** is a full-time student as he finally turned 26. He is a research assistant at the University of Maryland's Institute for Fluid Dynamics and Applied Mathematics. . . . **Tessa Orellana** spent last summer in Colombia studying tropical medicine. She is now in her last year at Harvard Med and is spending the year doing research in viral oncology. She plans to go into pediatrics. . . . **Rick Rudy** is a process control engineer with G. E. involved in making artificial lungs for use during heart-lung by-pass in surgery. During the summer he sang with the Tanglewood Festival Chorus and he has joined the Octavo Singers, performing major choral works in Schenectady. . . . Finally, **Dennis Sager** has taken a leave of absence from MITRE to return to the sacred halls of our alma mater for a master's in aero/astro. . . . That's all for this month. Remember to drop us a line.—**Gail** and **Mike Marcus,** c/o Technology Review, Room E19-430, M.I.T., Cambridge, Mass. 02139

69

I have received another large batch of notes from our classmates. I hope I continue to be "flooded" with mail. Be sure

to keep me posted on your activities.

Certificates of Appreciation were awarded this fall to 104 alumni whose efforts on behalf of M.I.T. in the 1971 Alumni Fund were outstanding. Thankyous and congratulations for making the drive a success go to **James P. Truitt, Jr.,** our class agent, and **Alan Rabinowitz,** course agent for the graduate school of city planning.

Wedding Bells

Jeff Weissman was married to Miss Linda Fleder on June 27, 1971. Linda is a 1970 graduate of Boston University. After teaching for one year at Brookline High School, Mass., and being declared physically unfit for the draft, Jeff is currently studying law at New York University Law School from whom he has received a Root-Tilden Scholarship. . . . **Gary B. Hirsch** was married in August of 1971 to the former Miss Linda Verdun, a psychology graduate of Jackson College and the University of Pennsylvania. Gary received his S.M. from the Sloan School of Management in June of 1971 and is presently working as a consultant with Pugh-Roberts Associates, Inc., Cambridge. His work primarily consists of studies in such social problem areas as crime, narcotics, and inadequate health care. . . . In a classmate marriage, **Jack Hirsch** and **Ame Street** exchanged wedding vows on December 21, 1969. Jack is currently a graduate student in physics at Harvard University while Ame is a graduate student in ocean engineering at M.I.T. . . . **Carl R. Bozzuto** was married on September 18, 1971, to the former Miss Alexandra Ratynski of Andover, Mass. They are presently residing in Windsor Locks, Conn. . . . **Alan Davis** reports he will soon be joining the ranks of the young marrieds. After seven years he and Miss Lynda Robinson have become engaged. Alan is presently in his third and hopefully last year of Ph.D. studies in computer science and is anxiously awaiting the snow to continue his winter activity of being a certified ski instructor at Park City, Utah.

Graduate Degrees and Continuing Education

Among the approximately 4,000 candidates awarded degrees by Harvard University on June 17, 1971, were the following classmates: Denis A. Bovin, M. B. A., Harvard Business School; David Chanoux, M.B.A., Harvard Business School; Richard W. Dorman, M.B.A., Harvard Business School; William Greenberg, Ph.D., John F. Kennedy School of Government; Gene K. Landy, A.M., Graduate School of Arts and Sciences; Anthony K. Lima, M.B.A., Harvard Business School; Robert J. Listfield, M.B.A., Harvard Business School; and John F. Walters, M.B.A., Harvard Business School.

Those continuing their pursuits for advanced degrees include the following: **Michael McNutt** has started his third year at the University of Illinois working towards his Ph.D. in solid state electronics. Mike adds that he wishes some of his "old fraternity brothers would write in to *Technology Review* occasionally." . . . **James Sicilian** is still working on his Ph.D. at Stanford University in nuclear engineering. . . . **Michael E. Solin** is in his third year at Yale University School of Medicine. His wife Enid is a management employee at the South New England Telephone Co. . . . **Eugene F. Mallove** entered the Harvard School of Public Health in September, 1971, for a program of study leading to the degree of doctor of environmental health, science, air pollution control. His wife Joanne is working toward her master's degree in applied piano at Boston University. . . . **Mark I. Ostler** is "still plugging away" at a Ph.D. in polymer science at Case Western Reserve University in Cleveland, Ohio. Mark lost his "bachelorhood" in August when he married the former Sandy Barnes of Cleveland in Las Vegas, Nev.

Richard Parker, his wife Susan, and their sons Joel, 3, and Jeremy, 2 months, are at Texas A and M University where Dick is working on his Ph.D. in oceanography. He left M.I.T. directly after graduation in 1969 for Texas A and M and reports he still has not gotten over the cultural shock. . . . **Robert Harry Parker** attended Cornell University after graduating in 1969 and received his master's degree in June, 1970. He is now employed by the Rand Corp. in their information sciences department. . . . **Jeffrey S. Passel** is working on his Ph.D. in sociology at the University of Texas at Austin. . . . **Gregory E. Peacock** is now working for Hughes Aircraft while seeking his master's degree at U.C.L.A. on a Hughes Fellowship. . . . **George A. Powch** has completed his M.S. in electrical engineering at Stanford University while working for Hewlett-Packard in Palo Alto, Calif. In September, George entered the M.B.A. program at Harvard Business School. . . . **Roy F. Quick, Jr.,** is currently at the Carnegie-Mellon University in a Ph.D. program in electrical engineering-biotechnology. Roy was named as an N.S.F. summer intern and was in Washington working for N.S.F. during July and August. On August 15, 1971, Roy exchanged vows with the former Ellen Kaufman, a 1970 graduate of Wellesley College, in Pittsburgh, Pa.

Evan P. Sampatacos was married in August, 1969, to the former Lori McIlvin, a 1969 graduate of Drew University. He is presently working for Martin Marietta in Denver, Colo., doing testing in their hypersonic wind tunnel. . . . **Robert A. Schaeffer** reports he has finally "been weaned from mother Institute." After four years as an undergraduate and two more as a D.S.R. staffer in the Unified Science Studies Program of the Education Research Center, Bob has become field secretary for MASS PAX. "More importantly" Bob married the former Elaine Coughlin on September 5, 1971. . . . **David Silverman** is presently in the department of chemical engineering at Stanford University. Having successfully passed his qualifying exam, Dave is now doing research in bio-engineering for his Ph.D. Dave reports the weather in California "sure beats that of the East Coast" to which I'll add "Amen." . . . **George C. Slusher** received his master's and mechanical engineering degrees from M.I.T. in February, 1971. He is now serving on active duty in the U.S. Air Force at the Air Force Flight Dynamics Laboratory at Wright-Patterson AFB, Ohio. He is doing work on advanced simulation techniques, particularly for the Control-Configured Vehicle program which will demonstrate benefits which may be had in aircraft performance by including sophisticated control systems in the initial stages of aircraft design. George has also recently purchased a horse—an eight-year-old Morgan gelding. . . . **John R. Smith** is "still employed" by Hughes Aircraft in Fullerton, Calif. He expects to receive his M.S.E.E. in computer engineering from U.S.C. in the spring of 1972. John also reports becoming crazy about skiing since taking it up in January.

Silvia Sorell has passed her preliminary exams for the doctoral program in physics at Berkeley. This past summer, she worked in a biochemistry laboratory at Weizmann Institute in Israel. . . . **James J. Stone** reports he has "been raising singing frogs for Mayor Kevin White's campaign." . . . **Michael P. Timko** entered basic training in the U.S. Air Force at Lackland A.F.B., San Antonio, Texas, on June 23, 1971. . . . **John L. Usher** received his master's degree in nuclear engineering in August, 1971, and will continue on towards his Ph.D. at the University of Florida. . . . **Lee Van Slyke** married the former Donna Lynne Kramer, a 1971 graduate of Simmons College. He and his wife are now happily living in suburban New Jersey. . . . **Hal R. Varian** has started his third year of graduate school at Berkeley and is working on a master's in mathematics as well as a Ph.D. in economics. . . . **Don Vawter** is now working for his Ph.D. in bioengineering at the University of California—San Diego, where he has a research assistantship from the department of medicine. Earlier, he had received his S.M. from M.I.T. in 1970. . . . **Eben Walker** received his master's degree from the Sloan School in June, 1971, and entered the army on August 1, 1971. After a three-month stay with the army, Eben will leave for Djakarta, Indonesia, where he has accepted a job with the Indonesian Government which is sponsored by the Ford Foundation. Eben would like anyone in the Djakarta area to look him up.

After graduation, **Mitchell Wand** took off for Stanford University to study in their computer science department. Disliking it intensely, he returned "to the womb of the Mother of Technology in January, 1970." In June, 1970, he married the former Barbara Freedman of Milford, Mass., a member of the class of 1972 at Brandeis University. While on a six-month reserve duty from October of 1970 until April of 1971, Mitchell was trained to be a combat engineer which he reports "is somebody who walks in front of the infantry looking for land mines." While employed as a mathematician by the Artificial Intelligence Laboratory of M.I.T., he is working towards his Ph.D. in mathematics. . . . **Allen Wiegner** is in the U.S. Public Health Service, working for the National Institute of Mental Health in Bethesda, Md. Allen "heartily recommends the Public Health Service as a means of fulfilling one's military obligation in a non-military, apolitical manner." . . . **Robert K. Wiener** joined the research

staff at the Draper Laboratories after graduation. Subsequently, he was laid off along with 149 other workers at IL-7 in July. Since there was no prospect for technical jobs in his view, Bob did the only natural thing—he formed his own company. Bob will send more information along "if I make some money." . . . **Mark Wuonola** has been working on a history of Delta Chapter of Theta Xi of which he was a member at M.I.T. Mark hoped for distribution of his research to his house's alumni in early summer.

Other Notes

Stephen Dreher, 3rd, is presently working for Applied Management Corp., a business management consulting firm in Denver, Colo., as a statistician ("even though I've never had a statistics course!"). Steve is also working for an engineering and surveying firm doing surveying and calculations. . . . **William Bengen** is currently employed by the Seven-Up Brooklyn Bottling Company as an environmental projects director. He is helping to set up a glass collection and recycling program as well as analyzing raw materials and supplies used by the company to provide for maximum reuse and recyclability. Bill is of the opinion that the beverage industry has been unfairly treated by the press for its contribution to solid waste which is in a relatively small proportion.

Bruce H. Parker is currently serving as a platoon leader and motor officer for a combat engineer company in Karlsrube, Germany. He is attempting to get transferred to a section which uses computers which Bruce expects to be a long, uphill struggle. . . . **Richard A. Pinnock** is presently serving as the squadron communications officer in the 2/14 Armored Cavalry Regiment of the U.S. Army located in Bad Kissingen, Germany.

Thomas J. Lamb, of Arthur D. Little, Inc., Cambridge, spoke at the tenth annual conference on air pollution control at Purdue University this fall. The conference is designed to inform and upgrade industrial engineers and others responsible for monitoring and control of fuel, boiler, and stack effluents. . . . The President's Inauguration Resistrants List as of October 5, 1971, included Niels O. Larsen, Robert Lotz, David E. Burmaster, and Mildred A. Hastbacka.

Those of us who doubt if anyone ever wins those crazy contests which constantly are being held will take note of the following news from **John M. Gonsiewski:** "Believe it or not, people do win contests! In August I went to London and Paris courtesy of Kent Cigarettes. What started out as a feeble use of my time (one had to make up all the words one could from the phrase 'Kent Micronite Filter Cigarettes') ended up in a bonanza. I took along my good friend **Clifford Hollander.** Since winning, I've been entering contests like mad, to little avail."

That does it for this time around. Write me, and who knows, but perhaps *Technology Review* will be running a contest sometime in the future. Prizes would, of course, include the following: First prize—one free year of study at M.I.T.; Second prize—two free years of study at M.I.T.—**Richard J. Moen,** Secretary-Treasurer, 412 Hastings Hall, Cambridge, Mass. 02138

70

Boston has just had its first snowfall of the long winter season. Laura has been playing for the Gilbert and Sullivan Society. Robert is readying his ski equipment for the slopes. Mayor White was re-elected. The *Phoenix* and *B.A.D.* made national news. Governor Sargent made a quick visit to the Sloan School.

"Cauliflower is nothing but cabbage with a college education. . ."

It was nice to hear from **Robert W. Powell** who is presently a graduate student at Penn State. Robert was married in his senior year at M.I.T. He also was a very good lacrosse defenseman. . . . **Thomas Devine** is studying hard, here at M.I.T., on his doctorate from the metallurgy department, investigating metallic medical implants. His wife, Trisha, is working as a secretary in the mechanical engineering department. . . . **David H. Hall** married the former Nancy Bouchard and is presently working on a Ph.D. in neurochemistry at Caltech. . . . **Thomas H. Derby, 3rd,** and **A. M.** (Sandy) **Harlow, Jr.,** are pursuing master's degrees at the Sloan School. . . . A month-long tour of Europe followed the marriage of **Alain J. Hanover** and the former Carol Mackta (Simmons '70). Alain is seeking his Ph.D. from Harvard. . . . A big "welcome" has been sent out by **James R. Spooner** from his residence in Nebraska. He is attending graduate school at Johnny Carson's alma mater.

After spending a year working for Underwriters' Laboratories, **Jack Confrey** decided to get an M.B.A. from University of Chicago. Drop a line to us about that jazz you've been playing lately. . . . **Robert G. Gerber** writes that he has completed the master's degree program in construction management at Stanford University. He is presently working for Consumers Water Co., Portland, Maine. . . . Another graduate of Stanford is **Howard Hoffman,** in environmental engineering. . . . **Steven C. Smith** is in the five-year program at M.I.T. Annie Smith, formerly Miss Kivisald '71 is helping with the finances by teaching out in Wellesley.

"We have medicines to make women speak; we have none to make them keep silence. . ."

Ronald J. Palinsky is completing his second year at Dartmouth Medical School. He married the former Barbara Spangler in late August, 1970. . . . Both **Mike Theerman** and **Maxim Daamen** are studying at Tufts Medical School. . . . **James C. Liang** writes that he is enrolled in the medical school at the University of California at San Diego, while **Wayne R. Porter** is starting his clinical clerkships at Duke Medical School.

"It is impossible to enjoy idling thoroughly unless one has plenty of work to do. . . (or) to work, and back to bed again. . ."

Joseph Di Liberto after receiving his master's degree from Harvard accepted a research position with Western Electric Research Center in Princeton, N.J. . . . Teaching physics and chemistry occupies most of **George E. Biehl's** time except for some occasional skiing and climbing. . . . Also teaching and enjoying it tremendously is **Frank Guillot.** Frank and his wife agree with W. C. Fields about Philadelphia. . . . **Donna A. Hill** and her husband, Herman "Butch" Hill, are living in Wayland on Lake Cochituate. She is working for Computer Systems Engineering as an analyst. . . . **Steven C. Chamberlain,** after leisurely finishing his thesis in economics, has found insurance selling and chess playing in Atlantic City more to his liking than driving a Cambridge cab. . . . **David** "close-call" **G. Luchaco** is helping the environment by working for Bendix Corp., on emission controls for internal combustion engines. . . . I sat and talked with **John Vliet** while attending the North-South All-Star Lacrosse game played at Tufts this summer. John is working traveling and superintending an apartment house on Beacon St.

Congratulations to our class officer, **Pamela Whitman,** for being elected to the M.I.T. Corporation for a five-year term. She is presently teaching at Shirley Industrial School for Boys. . . . **Carl Yankowski** having received bachelors' degrees in VI and XV is working as an analyst for Proctor and Gamble in Cincinnati. He and Sandy Griffith (Jackson '70), who is presently attending medical school at University of West Virginia, plan to wed early in June. . . . Also working at P. and G. is **Wayne Wenger,** who seems to be enjoying bachelor life.

The class noters would like to get a little something from P. M. M., Jr., J. R. C., J. R. H. and E. J. C. Letters of wisdom have already been received from Archie Bunker and R. M. N.—**Laura Malin,** Secretary, 406 Beacon St., Boston, Mass. 02215; **Robert Owen Vegeler,** Class Executive Committee Officer, 511 Beacon St., A-9, Boston, Mass. 02215

The M. I. T. Alumni Association—Spring '72

Alumni Seminar Series

The seminars, workshops, and short courses comprising the continuing-education program of the M.I.T. Alumni Association are planned by volunteer committees of M.I.T. alumni who are experts in their fields.

The objective is for alumni to share with one another the latest thinking and techniques on a variety of subjects important to them. Subjects are chosen primarily in response to the expressed desires of alumni, and the content of each program is tailored to specific needs. The common theme is an integrated perspective on each topic through the medium of experienced alumni helping other alumni in their endeavors.

Fees: Registration fees cover: Enrollment and attendance in a program; Reading materials; and Meals (meals not included in the Entrepreneurship Workshops and the Probability course). Spouses and other guests are welcome to the Saturday dinner in all two-day seminars for an additional fee as follows: New York—$12.00 per person; all other cities—$7.00 per person. Overnight accommodations are not included in the fee. Information on local facilities will be provided to all registrants. Each registrant must make his own hotel arrangement where necessary.

To Register: To register, please use the attached envelope. Complete the form on the envelope, enclose your remittance, and return. This form can be used for any seminar, workshop, or course, or any combination of them. Additional information on each program will be sent to all registrants as it becomes available.

How to Start and Operate a Small Business

In response to a continuing demand, the M.I.T. Alumni Association once again presents this timely, practical seminar for alumni who are:

- Entrepreneurs starting new ventures.
- Managers in young, independent business firms.
- Managers in new ventures of established companies.
- Consultants and technical specialists who desire an exposure to the fundamentals of business management.
- Individuals who provide services to new enterprises.

Conducted during a single weekend, the seminar focuses attention on the problems of getting into business and staying there under present economic conditions. Topics to be covered include finance, marketing and product development, production, accounting and control, attracting and holding staff, managerial style, and law.

Most speakers and discussion leaders will be alumni entrepreneurs or businessmen who work with entrepreneurs. Group discussions, enabling registrants to raise questions or problems, will play a prominent role in all meetings.

Cities & Dates: *New York:* March 4, 5, 1972
Boston: March 11, 12, 1972
San Francisco: May 6, 7, 1972

Fees: Alumni—$40.00/person; *Non-alumni*—$80.00/person

Managing a New Enterprise in Today's Economy

Directed toward the same audience as the seminar "How to Start and Operate a Small Business," this Entrepreneurship Workshop was developed for those who wish to study the subject in greater depth and who could meet on several different weekends. A workshop, while generally similar to a seminar in content and format, will offer a registrant five additional benefits: 1. Longer time devoted to individual topics, made possible by having four meeting days instead of two; 2. Receipt of a specially-prepared 50-page set of notes containing topic outlines and annotated reading lists; 3. Receipt of approximately 25 articles and booklets; 4. Unlimited privilege of attending Workshop sessions in cities other than where the registrant is enrolled; 5. Opportunity to be listed in and to receive a copy of the 1972 M.I.T. Entrepreneurship Register, a source of information about alumni who are entrepreneurs or are interested in entrepreneurship.

Each workshop consists of seven sessions, scheduled as follows:

Cities & Dates: Boston, Washington, D.C., and Los Angeles

March 4, 1972	(Session 1)
March 25, 1972	(Sessions 2 and 3)
April 8, 1972	(Sessions 4 and 5)
April 29, 1972	(Sessions 6 and 7)

Fees: Alumni—$90.00/person; *Non-alumni*—$180.00/person

Energy: Society vs. Technology?

This seminar is designed for alumni who have a professional interest in understanding the dilemmas of planning future energy use, and also for those who as concerned citizens want an understanding of the key issues.

With the demand for energy rapidly outpacing the supply, this nation approaches an energy crisis. The challenges of locating, processing and marketing new energy resources are compounded by the involvement in decision-making of numerous public and private agencies and by the added environmental constraints which we are now beginning to understand. Coordinated planning toward an equitable national energy policy is imperative.

It is with a sense of urgency that this seminar addresses itself to the problem of providing energy for the future. It repeats the unique and highly successful seminar on the subject held last May in Boston by bringing together representatives of the fuel industries, government and the private sector to consider how mutual goals can best be furthered. Underlying the discussion will be a realization of energy's fundamental contribution to 20th century life.

City & Date: Washington, D.C.: April 15, 1972
Fees: Alumni—$40.00/person: *Non-alumni*—$80.00/person

Probability-A Self-Study Course

"Probability" is a graduate level, self-study course. Even a cursory survey of engineering today reveals the widespread applicability of probability theory in almost every discipline. Such diverse fields as Systems Analysis, Random Processes, Decision Theory, Statistics, Quality Control, Automatic Control, Modern Management, Cybernetics, and Statistical Mechanics all have one common underlying structure—Probability Theory. The professional who lacks an understanding of probability is handicapped. The student who masters these principles, however, will find himself prepared to branch out into these and many other probability-based subjects.

Aimed at those who wish an introductory or refresher course, "Probability" will benefit anyone who can pass the pre-test—practicing engineers and industrial scientists, senior executives, technical managers, technicians, and college students. The amount of time an individual devotes to "Probability" depends upon his background, time constraints and objectives. You can take it for a sound grounding, or as an overview or audit, depending on your individual needs. The course will consist of eight evening sessions, two hours each, during February and March.

City & Dates: New York: February, March 1972
Fees: Alumni—$90.00/person; *Non-alumni*—$240.00/person

Technology and the Economy in the '70's

- Where will the opportunities in technology lie in the 1970's?
- What areas of research are projected for the future by private and public sectors; where will they find funding?

It is the purpose of this seminar to bring together experts from industry, government, and the academic world concerned with those areas of technology which are likely to be of paramount significance in the 1970's. Large industries project long range plans based on the evaluation of future needs; the Federal Government has announced the New Technical Opportunities Program which will establish priorities for research and development; and universities are assessing new programs of study and research. The participants in this seminar, all of whom have been involved in establishing future priorities, will discuss general economic forecasts as well as specific technological opportunities in numerous fields including: computers, energy, communications, transportation, building construction, services, chemicals, electronics, and aerospace.

Cities & Dates: Los Angeles: (tentative) March 18, 19, 1972
Boston: March 25, 26, 1972
New York: April 21, 22, 1972

Fees: Alumni—$40.00/person; *Non-alumni*—$80.00/person

The Future Character of the Urban Fringe

As the intensity of urban land use increases, no longer is there room for human negligence in the use of this most precious resource. Your fellow suburban residents are making the decisions today that will determine the shape of our towns and neighborhoods in the 1980's. How can you become involved in the decision-making process and affect the direction our land use will take? What can we learn from the baffling social, legislative, and economic trends of 1971 so that we may plan for tomorrow more wisely? Though not easily formulated and even less easily answered, these questions deserve our careful consideration whether we be city planners, public officials, or citizens who will have to live with what tomorrow brings. "The Future Character of the Urban Fringe" investigates factors which will shape the character of our future living with the aid of technical innovations now becoming available. The seminar will examine the pragmatic facts—economic trends, population statistics, legislation, political realities—and then probe the options open for us in the future. Experts in the areas of government and private planning will stress our stake in the quality of life in the 1980's.

City & Dates: Boston: April 29, 30, 1972
Fees: Alumni—$40.00/person; *Non-alumni*—$80.00/person

Use the envelope to register for any or all of the programs...

Thinking about...

opportunities in new technologies?
probability theory & real applications?
the urban fringe & its problems?
how to start & operate a small business?
providing energy for the future?
entrepreneurship & its problem areas?

Here's your chance to do something...

Learn the answers to questions you have on these subjects...he
the opinions of authorities in these fields...discuss the implicatio
You'll have this opportunity with the new Spring '72 M.I.T. Alum
Seminar Series...short courses and workshops covering topics
interest for your career and your community. More details and regi
tration information are on the inside of this cover.